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The Month.

THE CHARING CROSS DISASTER.—No failure within modern times has caused more perturbation in engineering circles and among the general public than the catastrophe at Charing Cross station. Many railway accidents and fires have been responsible for greater loss of life, and more serious collapses of structural works have occurred, notably in the United States, and quite recently in Madrid. But railway disasters and fires are correctly placed in the category of purely accidental misfortunes, while the failure of American railway bridges and other structures, and of the Madrid reservoir works, are known to have resulted from inadequate strength, due to flimsy design or bad workmanship. Charing Cross station, on the contrary, was well-designed and well-built, and for this reason its partial collapse with only a few minutes' warning, has aroused widespread doubt as to the stability of other important engineering works, and indeed as to the safety of innumerable buildings whose very existence depends upon the continued strength of steel girders and joists, hidden from sight, but not protected from corrosion by the brickwork in which such members are embedded. The protracted life of many historic iron structures built by the early engineers, sufficiently proves that with proper maintenance there is little to fear in the case of bridges and buildings open to inspection. As to iron and steel applied in architectural practice, we have very little more than negative evidence. So far as our information extends, no building has collapsed hitherto owing to the failure of wrought iron or steel members by fatigue, or as the result of corrosion. But there is no saying what may happen in the future. The practice of burying unprotected steel members in walls, where they are exposed to atmospheric influences and to moisture percolating through the brickwork, is one that is obviously contrary to the dictates of prudence and reason. Even if structural engineers do not feel disposed to adopt concrete-steel they would be wise to employ cement grout as a protective wash for all hidden steel work, and cement concrete as a further shield against the penetration of moisture. With regard to purely engineering structures, we believe there is no reason for apprehension providing all parts are subjected to efficient inspection, cleaning, painting and repair at sufficiently frequent intervals. It is far from our intention to anticipate the conclusion of the coroner's inquest, the Board of Trade inquiry, or of the independent investigation to be conducted by the railway company. We have reason, however, for entertaining the trust that the results of these inquiries will fully justify the faith which has been

reposed for the last two or three generations in wrought iron and steel as trustworthy materials of construction.

PARIS MOTOR EXHIBITION.—Unlike its predecessor at Olympia, the recent International Automobile Exhibition was in a remarkably backward state on the day of opening, and the same applies to the condition of the paths of which so much complaint was made last year. In respect of accommodation, the Grand Palais affords far more adequate facilities than any building in this country, while the decorations were far more elaborate than anything attempted at Olympia. With regard to the exhibits themselves, our own exhibition presented greater interest and variety, for it included all the latest British models and practically all the latest Continental types. We are glad to be able to mention the fact that many of the leading British makers were well represented in Paris and to congratulate our neighbours upon the undoubted success of their exhibition.

INDIAN LOCOMOTIVES.—The long-standing grievance of locomotive builders against the inconvenience caused by the vagaries of consulting engineers in respect of engines for the Indian Railways is too well-known to require comment. After the discussion of this question in our columns, some three or four years ago, the Engineering Standards Committee, with the assistance of a conference between the consulting engineers and locomotive manufacturers of the country, issued a report embodying designs for five types of standard engines which are intended to cover all requirements for main line traffic in India. The first issue of the report was made in November 1903. Since that date the first standard engines have been built, and in the light of experience gained from them, certain revisions have been found necessary which are embodied, but not clearly set forth, in the second issue, published during November last year. The body of the report includes, for the guidance of designers, two series of 87 resolutions, relative to the "5 ft. 6 in." and the "metric" gauges, and at the end of the report are full-page plates giving front and end elevations of the standard passenger and goods engines and tenders, with data as to dimensions, heating surface, weight, tractive force, and other essentials. Of course, some details recommended are open to criticism, and it may be thought that modern developments ought to have received more adequate recognition. Still, it must be remembered that the standard types settled are considered by those best qualified to judge to be such as will prove most generally useful at the present time on the majority of Indian railways, and if makers could be definitely assured that the designs will be adopted for a period of years, the benefit to the locomotive industry of Great Britain would be immense.

STEAM TURBINES.—Within the past few weeks we have had quite an outburst of information relative to steam turbine design. Mr. C. A. Parsons has been particularly active, his record comprising a lecture at Newcastle, an article in the Times Engineering Supplement and the joint authorship with Mr. Gerald Stoney of a paper read before the Institution of Civil Engineers. At Sheffield, Professor Ripper has delivered an instructive lecture entitled "Some First Principles of Steam Turbine Design," and various engineering journals have budded out with accounts of sundry turbine steamships recently built and in course of construction for the Cunard and other companies. There is no doubt that interest in the steam turbine has been wonderfully stimulated during the past few months, and it is quite right that engineers should have every opportunity of obtaining information direct from the authorities whose names we have mentioned. The turbine plant, firmly rooted in this country, has spread its branches to other parts of the world and above certain limits it bids fair to oust the reciprocating engine. For instance, in marine work, the lower limit for economy at present is about 5,000 h.-p. owing to problems connected with propeller efficiency, and in stationary land engines the same limit may be taken at 1,000 h.-p. That is to say, up to 5,000 h.-p. for marine engines, and to 1,000 h.-p. for stationary engines, the reciprocating type still holds the field for economy of steam consumption. It must not be forgotten that the modern tendency to prohibit the use of oil in steam engine cylinders, and the increasing use of superheated steam, places the turbine in a very favourable position, and that the possibility of expanding steam right down to condenser pressure is another reason for anticipating further economy from the turbine.

THE GAS TURBINE.—However fascinating the idea of the gas turbine may be, it is

tolerably clear that we cannot hope to see it realised in a really practical form as an internal-combustion motor until our present knowledge has been considerably extended. The great difficulty, of course, is the lack of a material capable of withstanding, the action of a continuous jet of high-temperature gas. The temperature of 2,000° C., common in cylinder gas engines, is far above the melting point of platinum, even the lower temperature of between 1,500 and 1,600° C., obtaining in the most economical practice, is coincident with the melting point of nickel, and the lowest possible temperature would be higher than the melting points of iron and steel. Therefore, until a new metal, or a new alloy of existing metals, has been discovered that will resist temperatures much above those which any known metal is capable of withstanding, the internal-combustion turbine must remain an abstract problem. Recognising the impossibility of designing a turbine on the desired lines, the trend of experimental and theoretical investigation is towards the design of a turbo-motor utilising kinetic energy generated by the explosion of gas in an outside combustion chamber. Another proposal is the gas-steam turbine, advocated by Professor Reeve. These alternatives are feasible, but, as Mr. Dugald Clerk showed in his presidential address to the Junior Institution of Engineers, neither of them would give particularly high efficiency. It is not impossible, however, that economical results might be obtained with the gas-steam turbine installed in conjunction with a gas or oil engine in such a way as to constitute the low-pressure end of the combination, and so serve to utilise part of the heat furnished by the water jacket and the exhaust gases.

TESTS OF ELEVATOR PLANT.—A useful series of tests upon hydraulic lifts in the Trinity Building, New York, under ordinary working conditions, has given results that ought to be of practical utility to engineers for comparison with data obtained in other buildings where lifts have been installed. The tests to which we refer are described by Mr. A. J. Herschmann in a paper read last month before the American Society of Mechanical Engineers, the results being tabulated under two general heads relating to boiler evaporation and economy, respectively. Very complete data are given as to the conditions under which the tests were conducted, but the results are too numerous for quotation in detail. We may point out, however, that the pumps included in the elevator plant were a duplex compound pumping engine and an ordinary horizontal fly-wheel pump, and that the former consumed no less than 44·1 per cent of steam in excess of the latter.

THE WITHAM RAILWAY ACCIDENT.—In his report to the Board of Trade upon the disaster at Witham Station, Colonel Von Donop suggests that the derailment "was probably due to a weakening of the line . . . owing to the work which was being carried out by the platelayers." This is not a very convincing theory, and we think it more likely that the accident was due to fracture of the knuckle chair and through bolt at the crossing. The evidence given at the Board of Trade enquiry showed that the permanent way was in good condition generally, but the inspector has expressed the opinion that the construction is not up to the highest standard. Having regard to the fact that the wrecked train was travelling at a speed of nearly 70 miles an hour, there is some reason for doubting the adequacy of the permanent way for the required duty, as we suggested in a previous note.

THE ASSOUAN DAM.—A very striking illustration of the enormous force exerted by water in flowing from openings under comparatively small heads, is furnished by the erosion of the river bed below the Assouan Dam. By the employment of the low-level sluices it is easy to arrange matters so that the maximum head is less than 30 ft., but even with the velocity due to this head the water has been able to tear out rocks from the bed of the Nile, one of these masses of stone having the maximum dimensions of 17 ft. by 12 ft. by 7 ft. and representing a weight of somewhere about 60 tons.

SUPERHEATED STEAM.—According to the most recent investigations, the specific heat of superheated steam increases with increase of pressure and decreases with increase of temperature. For instance, for steam at 401° Fahr., the specific heat is 0·58 at a pressure of 63·5 lb. per sq. in and 0·62 at 100 lb. pressure. Again for steam at 100 lb. pressure per sq. in. the specific heat is 0·622 at 405° Fahr. and 0·568 at 534° Fahr.

FLOW OF AIR THROUGH ORIFICES.—For determining the volume of air flowing into the atmosphere through circular orifices, and under small differences of pressure, the

formulæ available do not give results that are sufficiently accurate for all purposes. Engineers who have occasion to measure the quantity of air discharged by fans, blowers, air compressors, and kindred appliances will find some practical data in the paper read last month by Mr. R. J. Durley, of Montreal, before the American Society of Mechanical Engineers. The author therein describes a series of experiments intended to ascertain the law governing the flow of air through orifices in thin plates, at low heads; and to measure the air discharged, in such a manner that the experimental conditions could be reproduced at any time for laboratory use.

SUCTION-GAS PRODUCERS.—So largely has producer gas been adopted by manufacturers in the Midlands that the Birmingham gas committee have been obliged to recommend a further reduction in the rates for power-gas supplied from the corporation gas works. From a recently issued report we gather that the committee fully realise the serious situation likely to follow the general employment of power-gas plants in the district. The circumstances afford a striking example of the risks to which municipal traders may be sometimes exposed. Makers of suction-gas producers are exceptionally busy in the Birmingham district, and the compactness of this type of producer is certainly a feature commending it to the proprietors of factories where floor space is limited. We must observe, however, that suction-gas as at present produced is not cleansed in any way—an omission that may have to be made good for the purpose of avoiding injury to the cylinders and working parts of engines in which the gas is employed. The point is one that should not be overlooked by the users and makers of suction-gas apparatus.

THE PRESERVATION OF TIMBER.—Among the many different processes introduced for the protection of timber, the injection of creosote still retains its popularity for certain classes of constructive work. We are afraid that engineers do not always remember that the value of the process depends absolutely upon the quantity of oil injected and the depth of penetration. It is rarely the case that the purchaser can obtain reliable information as to the quantity of oil injected, even if he has correctly calculated the proper amount for the batch of timber to be treated. As for the depth to which the oil penetrates, that is a matter depending upon the thickness of the sap wood, for the heart wood is practically impervious. In a paper submitted to the American Society of Civil Engineers, Mr. H. R. Stanford makes some suggestions for a specification to govern the creosoting of green timber. The most useful clause proposed is one providing that the quantity of oil injected shall be gauged by the relative weights of full-sized pieces, green and treated, respectively, the determined quantity being taken as the difference between the treated and green weights, after reducing the latter by two-thirds of 1 per cent for each pound of oil required per cubic foot of timber.

CANADIAN WATERWAYS.—No better proof could be found of the wise foresight exercised by the Government ever since 1867, than the efficient state of the canals supplementing the great natural waterways of Canada. The cheapness of water transport so provided has continually stimulated railway engineers to improve competitive traffic facilities, until at the present time the Canadian railway services are unequalled for cheapness and efficiency. The engineering equipment of the canals is of the most modern character, and the adoption of electric lighting facilitates the conduct of navigation by night as well as by day. For the rapid handling of materials at the ports of the great lakes, the most improved types of mechanical plant are employed, so that lake steamers of 7,000 tons can be loaded in four hours and discharged in ten hours. In fact, at one port the large quantity of 5,210 tons of ore has been discharged in less than four hours, the actual rate being 22 tons per minute. Ship building on the great lakes proceeds apace, most of the vessels being built in the three Canadian yards at prices which could scarcely be approached even in Great Britain. Internal navigation suffers, however, from the rigid exclusion of Canadian vessels from American lake and river ports, while on the other hand the Canadian ports are free to all comers. But Canada has a remedy at hand in the construction of the proposed Georgia Bay Canal, by which communication will be established between the great lakes and Montreal without the necessity for the transhipment of cargo. This canal will be of immense benefit to British North America; among the results anticipated being the diversion of United States traffic to the Canadian route, augmentation of the mineral and grain industries in Canada, and the utilisation of many sources of water power along the new route, with the consequent development of new industrial regions in the Dominion.

Sub-Aqueous Foundations, with Recent Examples of the Use of Compressed Air.—I.

By J. E. TUIT, M.Inst.C.E.

THE employment of compressed air in connection with the construction of foundations has been steadily gaining favour amongst British engineers and contractors, and is now generally adopted wherever work of any magnitude has to be executed, as it is in many respects preferable to any other system, although accompanied by some disadvantages.

On the Continent, and especially in France, the pneumatic process is generally resorted to, even for such moderate depths as 15 ft., and a type of diving-bell is much used where foundations have to be put in under even a still less head of water.

The chief advantage of employing compressed air, from the contractor's point of view, is the security it offers that, whatever difficulties may be met with, they can be probably surmounted, while the use of other methods cause constant anxiety in case something unforeseen may happen, that necessitates the pneumatic process having after all to be finally resorted to. One of the risks in the sinking of cylinders and caissons is the possibility of encountering some obstruction, such as large boulders, or logs of timber, &c., the removal of which would be exceedingly difficult, if not impossible, if any other system than compressed air was being used. An experience of this kind was met with only a few months ago while sinking one of the cylinders for the new bridge now being constructed over the Nile at Cairo. The river being one-third of a mile wide where the structure is being built, there are no fewer than twenty-eight cylinders to sink. These are generally 18 ft. diameter at the bottom, and have to be taken down to 93 ft. below the level of High Nile. After this portion of the work was well advanced, and many of the cylinders completed, one of them which had been sunk almost to the required depth, encountered an old barge, which had no doubt been buried in the river for centuries, and which, being directly under the cutting edge of the cylinder. most effectively stopped any further progress being made with the sinking. Fortunately the pneumatic system was being used, and but little difficulty was experienced in removing this obstruction, but a very serious delay would have been occasioned had it been necessary to employ divers to do this work.

Another advantage of the compressed air system is that it permits of the foundations being thoroughly examined, and properly cleaned and levelled, before the masonry or concrete work is commenced. This consideration alone is frequently sufficient to make its adoption desirable, if not for actually sinking the cylinders, at least for ultimately affording facilities for ascertaining that the foundations are satisfactory and that the work has been properly executed.

The first attempt to use compressed air for such work was made by Smeaton in 1784, in connection with Ramsgate Harbour, and Smiles in his "Lives of the Engineers" tells us that, "In carrying out the elongated pier, Smeaton first employed the diving-bell in building the foundations, making use of a square wooden chest, partly of iron, weighing about half a ton. It was 4 ft. 6 ins. in height and length, and 3 ft. wide, affording room for two men to work in it; and they were provided with a constant supply of fresh air by means of a forcing pump placed in a boat which floated above them," We are also told that when Rennie was engaged on these same works in 1807 he found the old bell that Smeaton had used, and taking it as a model, he so much improved it, that no important change in its construction has since been made.

Diving-bells of large size have frequently been employed in recent years for sub-aqueous work. In the construction of the North Wall at Dublin, a bell 20 ft. square at the bottom, weighing

eighty tons, was used for setting the 350-ton blocks of concrete. In this case access to the air chamber was obtained by a wrought iron shaft and air lock, very similar to what is now generally employed for caisson work, so that it was not necessary to raise and lower the bell to allow the men to enter or leave it.

Another very successful application of a floating bell or caisson was made in 1878 by Mr. H. Hersent, who undertook to remove part of the rock in Brest Harbour, and thus increase the depth of water at low tides from 17 ft. to 25 ft. Three bells were employed for this purpose, two of which were about 34 ft. by 27 ft., the third being somewhat smaller. They were raised and lowered with great ease, by letting the water enter or leave air-tight compartments provided for this purpose. Access to the working chamber was obtained by means of a central shaft 10 ft. in diameter, at the bottom of which the air-lock was placed. Each of the larger bells cost £2,000, and would accommodate twenty-eight men, who were capable of removing daily twelve cubic yards of the material.* Somewhat similar caissons have also been used by French contractors for the foundations of Garrit and Mareuil Bridges (1880), and those of the Weir at Coudray (1885).

It is surprising that this system for excavating and levelling sub-aqueous foundations is not more generally adopted in this country at the present day. Now that cast-iron has been so largely superseded by steel, diving-bells of very large size and ample strength could easily be constructed without being cumbersome, a weight which our modern lifting appliances are perfectly capable of handling.

At the Dover Harbour Works (1898) several such bells were, however, used; but these were comparatively small, the largest, which weighed forty tons, being only 17 ft. long by 11½ ft. wide and 6½ ft. high. It was built of steel plates riveted together, and was so arranged that it could be loaded with cast iron as required. The bells were used for excavating purposes and levelling foundations whenever the weather permitted. This work was done by four men, working four-hour shifts, although the pressure was sometimes as much as two-and-a-half atmospheres above the normal.

Ordinary divers have been known to work for short intervals at a depth of 200 ft., and be thus subjected to a pressure of 87 lbs. per square inch; but 150 ft. may be taken as the limit for work done in this way, and even at this depth, the men can only remain under water for very short periods at a time. Men in good health can work safely at depths of 60 to 90 ft. for three to four hours at a time, but the length of a shift must be much reduced as the depth of water increases.

The design of caissons and cylinders that are to be sunk by the pneumatic process requires the greatest care, and special experience. A well thought out scheme effects economy, and reduces to a minimum the time necessary to carry out the work. The chief matters for consideration are, however, those upon which not only the health, but even the lives of the workmen depend.

It cannot be said that any fundamental changes in design have been made since the time when the advantages accruing from the use of the compressed air system became generally recognised. There have been, however, many improvements in the details of the plant required, and the details are of the utmost importance in making designs for work of this character. The caissons used at the St. Louis Bridge over the Mississippi (1870) afforded good examples of such work at the time when it was being introduced on a large scale, and the somewhat similar caissons at the Forth Bridge (1883–1890) exhibited a still further development of the system. In both cases the greatest attention was naturally given to this portion of the work, but the requirements were so special that many of the ingenious devices that were used can

* Minutes of Proceedings, Inst.C.E. Vol. lxl., page 261.

but rarely be adopted in ordinary bridge-work.

At the St. Louis Bridge * the caissons for the east pier and abutment had to be sunk 99 ft. and 108 ft. respectively below the ordinary water level, a greater depth than had been previously attained. That for the pier was provided with an air shaft, no less than 10 ft. diameter, and the air-lock was placed at the bottom, within the working chamber. Such an arrangement would, of course. only be suitable for caissons of very large size, as there is generally no room to spare in the bell. One of the advantages thus obtained was that the men were not obliged to ascend the air shaft under pressure, and were thus spared unnecessary fatigue, which, at that time, was considered to be one of the chief causes of illness. So much importance was attached to this that the air-shafts were provided with circular stairs, instead of the ordinary ladders, and even these were subsequently replaced by lifts, that the men might not have to unduly exert themselves immediately after leaving the air-chamber.

The Hawkesbury River Bridge, New South Wales (1886-1889) affords another good example of deep foundations, one of the piers having been sunk to a depth of 162 ft. below high water. In this case the caisson, which was rectangular in plan and measured 52 ft. by 24 ft. at the bottom, was sunk by grabs. The employment of any other system for the purpose was impracticable, the material of the river bed being mud, extending to a depth varying from 60 ft. to 170 ft., and overlying sand. The greatest depth of water that had to be contended with was 77 ft., and the range of the tide 7ft. The caissons were sunk well into the sand as the maximum pressure on the foundations is as much as 9 tons per sq. ft.

At the Poughkeepsie Bridge (1889) over the Hudson, about eighty miles above New York, the piers had to be carried down nearly as deep, and very large timber caissons were sunk in a similar manner, the material being practically the same as was met with at the Hawkesbury Bridge.

Nearly all large caissons have been constructed slightly larger at the bottom than at the top, with the intention of somewhat reducing the skin friction. In those for the Forth Bridge this batter was 1 in 48, but for the large shafts at the Blackwall Tunnel (1891) it was reduced to 1 in 100. The general concensus of opinion now appears to be, however, that there should be no batter at all; or, at least, if any is provided, it should not exceed 1 in 300. Even then it would be preferable to make the bottom 20 ft. to 30 ft. vertical, that it may be easier to keep the caisson in an upright position during the process of sinking. The amount of skin friction of course varies very considerably with the nature of the soil passed through, and in one of the Blackwall Tunnel caissons, when its cutting edge was entirely unsupported, it was found to be 5½ cwts. per sq. ft., while in clay and ballast.

Many experiments have been made from time to time with the object of ascertaining what value can be placed upon skin friction, and the results obtained have been no doubt fairly accurate for the particular case under consideration, but they do not admit of general application. As a matter of fact the friction may vary between 1 cwt. and 7 cwts. per sq. ft. of rubbed surface, depending upon the nature of the soil, the depth sunk, and the time that has elapsed since the work was completed. It has naturally a different value for smooth cast iron cylinders, and caissons built up of iron or steel, and would be considerably modified, if, as generally happens, the cylinder or caisson became out of the vertical during the process of sinking.

Special attention should be given to the connection of the air-lock to the air-shaft as the upward force to be resisted may be very considerable. The same remark applies generally to the construction of the roof of the air-chamber, especially where it is connected to the

* A History of the St. Louis Bridge, by C. M. Woodward, 1881.

sides of the caisson, it being difficult to make such junctions air-tight. The joints in the air-chamber and shafts should all be carefully caulked, otherwise great trouble is caused by leakage, and the loss of air costs more than the expense that would have been entailed by doing the work properly at first. The number of air-shafts that should be supplied also demands careful consideration, as the progress of sinking has frequently been impeded by insufficient provision being made for removing material as quickly as the men below can fill the skips. For large caissons it is usual to provide several shafts, and in those for the Alexander III. Bridge (1897) over the Seine at Paris, which are about 145 ft. by 110 ft., no fewer than ten shafts 3ft. diameter were employed.*

Even such small matters as painting white the interior of the air-chamber and shafts, in order to obtain as much reflected light as possible, should not be neglected. The electric light is far preferable to all other illuminants for use in the air chamber, and should be used for all works of any magnitude. Several of the ordinary incandescent lamps are found to be more satisfactory than an arc lamp. Candles and oil-lamps give much trouble, owing to the smoke, and their vitiating effect on the atmosphere, and it should not be forgotten that at a pressure of about 30 lbs. per square inch above the normal, the wicks will rekindle, after being blown out, and consequently the risk from fire is increased.

The quantity of air required can only be ascertained by trial, as the leakage and other factors which determine it vary in every case. Each man requires about 4 cubic ft., and each candle about ¼ cubic ft. of air per minute, and at least three times these amounts should be supplied. In the case of the Alexander II. Bridge over the Neva (1875-79), 820 cubic ft. of air per hour was supplied for each man, and this quantity was found to be ample. Still, much of the illness that is usually experienced by the men working in compressed air is clearly attributed to the quantity of the air which is supplied to them being insufficient. The air should be analysed from time to time, and if it is found to contain more than one part of carbonic acid gas in a thousand, the supply should be increased. At the Blackwall Tunnel there were six air compressors of a total capacity of about 1,500 horse-power, which, during the time that the work was being carried on in the loose ballast, supplied as much as 10,000 cubic ft. of air per minute, most of which was, of course, lost by leakage.

The cooling of the air after compression is also of great importance, that the air chamber may be kept at a temperature at which the maximum efforts of the workmen may be obtained. Attention to this matter is also essential that the men may not be exposed to a great change of temperature when they leave the air-lock. Where much air is needed it is generally preferable to have duplicate engines and compressors, rather than a large one, as this arrangement provides against the risk of breakdowns, besides being more convenient.

The early designs for air-locks have been considerably modified during recent years, and the heavy type such as was used at the Forth Bridge has been superseded for ordinary work by that shown in Figs. 1 and 2. In this design, it will be noticed, the material lock is placed above that for the men, and has a small engine attached to it for hoisting the skips. The men's lock is divided by a longitudinal bulkhead, so that it is really equivalent to two locks, and this is a matter of much importance when the saving of time is essential. The air can be supplied to the caisson by a 2-in. hydraulic pipe connected to the air-lock.

It is hardly necessary to point out that all the details of this portion of the plant require the most careful study, and it will be remembered that one of the serious accidents that occurred at the Alexander II. Bridge over the Neva was due to the faulty construction of

* *Le Génie Civil.* September, 1897.

one of the air-locks. The air-locks used for the material shafts at the Mirabeau Bridge (1896) over the Seine at Paris, were so constructed that the operation of raising and lowering the skips automatically opened and closed the valves controlling the air, and this type of material lock is largely used on the Continent.

Caissons constructed partly or wholly of timber are frequently used, especially in America, where the price of this material admits of it being economically employed. In fact it has been stated that nearly 85 per cent. of all the pneumatic foundations made in the United States are formed with timber caissons and that such have been used with great success.* The timber caissons at the East River Bridge, New York (1896-1901) are good examples of this class of work on a large scale. Similar caissons have been used for the Haarlem River Bridge, and for the 1,600 ft. span of the Williamsburg Bridge over the East River which has just been completed. The foundations for the Manhattan Suspension Bridge and Blackwell's Island Bridge, New York, as well as the 1,800 ft. span bridge at Quebec, all of which are now in course of construction, will also be of timber.

Such caissons offer several advantages. Their buoyancy relieves the pressure upon the foundations, and although it is not usual in this country to take into consideration the reduced weight of a pier in water, yet on the Continent and in America the practice is the reverse, thus allowing the area of the foundations to be reduced. Timber can also generally be obtained at once, and the construction of a caisson may be commenced immediately a contract is let, and can be frequently completed before it would be possible to obtain one made of iron or steel. It must not be overlooked, however, that air at a pressure of a little over two atmospheres will pass freely through most timber, so that some kind of coating has to be used to render the work air-tight should it be necessary to provide for such a pressure.

FIG. 1.—BRIDGE OVER THE NILE AT CAIRO. SINKING THE CYLINDERS.

* Trans. American Soc., C.E., page 142, 1904.

Illness caused by Compressed Air.—There are no Government rules in this country or America relating to the use of compressed air, but on the Continent those in authority often insist on certain precautionary measures being observed. The regulations of the Austrian Government are very complete, and are usually adopted, not only in that country, but also in Germany.* It should here be mentioned, however, that, generally, such rules are not arbitrarily enforced, the authorities being willing to consider any reasonable suggestion for modifying them in special cases. Those relating to men working in compressed air, take into consideration all the important questions that generally arise in carrying out such work; but only require such measures being adopted as no contractor in this country would be likely to object to. At the present moment the Dutch Government is contemplating legislation of a similar nature, and two of their representatives recently visited this country to collect evidence bearing on the subject. Much attention has also been given to the effects of working in compressed air by medical men, some of whom have had special opportunities of investigating the cases of illness as they have occurred. At the Blackwall Tunnel, the London County Council appointed Dr. E. H. Snell, Resident Medical Officer, and his subsequent work* is a most important contribution to medical literature.

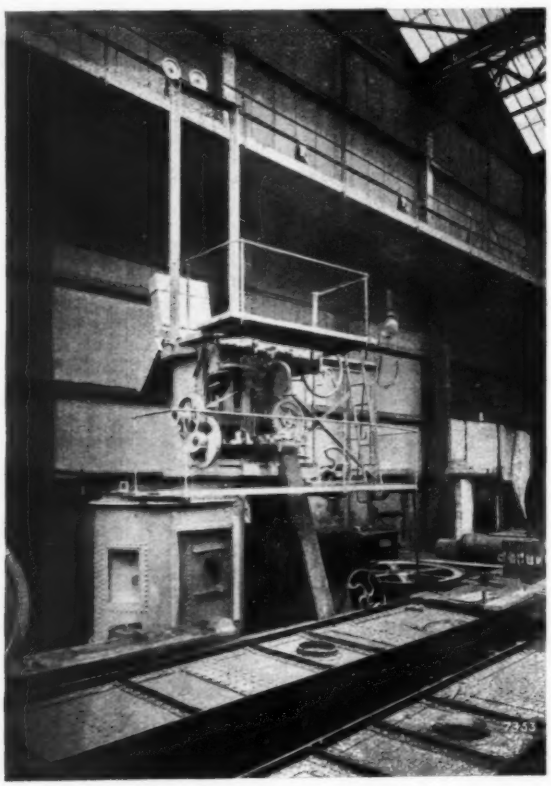


FIG. 2.—MODERN AIR LOCK FOR MEN AND MATERIAL.

In no engineering undertaking in this country have the workmen employed ever received such special consideration as the London County Council exhibited for the welfare of those engaged in the construction of the Blackwall Tunnel. They obtained Parliamentary Powers to compensate men who had been injured by working in compressed air, although such were not in their employ. They specified that lifts and resting places should be provided for them, in addition to a compressed air re-immersing

* See *Centralblatt der Bauverwaltung*, 1898, No. 26.

* "Compressed - air Illness, or so - called Caisson Disease," by Dr. E. H. Snell. London, H. K. Lewis, 1896.

chamber fitted with locks, and they would not allow any workman to be engaged for this work without his fitness being proved by previous experience, or by medical examination. The freedom from serious disease amongst the men employed, notwithstanding the air pressure was sometimes as much as 37 lbs. per sq. in. above the normal, is partly attributed to the experience gained during the building of the tunnel in his opinion, partly to the advantage of the beneficent auspices of the County Council on the one hand, and on the other, to the thoughtfulness and care shown by the contractor.

We must, however, turn to the descriptions of Continental work, should we wish to consult exhaustive investigations on such subjects. The report of the committee appointed by the Russian Government to watch the construction

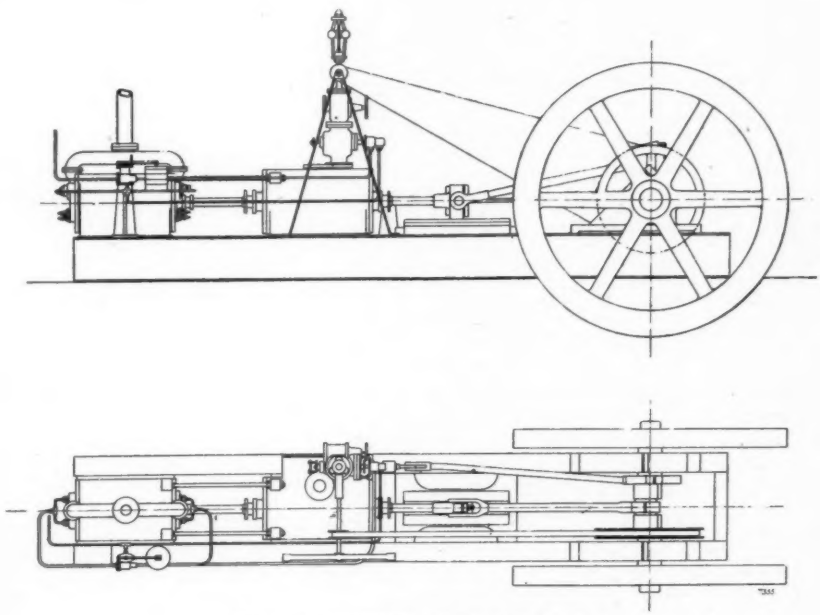


FIG. 3.—AIR COMPRESSING ENGINE: 24-IN. STROKE.

under the Hudson River, New York, where a re-immersing chamber was used for the first time by Mr. E. M. Moir for men who had shown symptoms of illness on leaving the air-locks.

Dr. Snell tells us that no deaths occurred at Blackwall, although there were many cases of illness, he having notes of over two hundred cases, a large number of which, however, could not be described as serious. He also says that this happy result might be traced, of the Alexander II. Bridge over the Neva consisted of no less than five volumes or about two thousand pages.

The remarks, however, made by L. Brenecke in 1897 contain practically all that can usefully be said at present on the subject. He says,*

"It is well known that deaths have occurred in connection with the use of high pressures. Most of the recorded cases have been with

* Minutes of proceedings Inst.C.E. Vol. cxxxi., p. 398.

pressures two atmospheres or more above the normal; but that danger does not arise from high pressure in itself, but rather in its too rapid reduction, is shown by a case where a sudden reduction of + 0·3 atmosphere to the normal proved fatal, and by an experiment when +5·4 atmospheres was endured without ill effects, when the reduction in pressure was gradually accomplished over a period of three hours three minutes. Post-mortem examination had revealed in many, but in by no means all, cases, collections of gas in the heart or veins, giving rise to the theory that these deaths were caused by the bursting of small gas bubbles, impeding the circulation of the blood, and thus stopping the action of the heart, or causing it to be overstrained in clearing away the obstructions. Drs. Richard Heller, Wilhelm Mayer, and Hermann V. Shrötter, have lately (1894) investigated this subject thoroughly, dealing with 129 deaths, of which thirty-eight were divers and ninety-one caisson workers, while in forty-two cases a post-mortem examination was made. They agree with the above theory, first stated by Paul Bert in France, and are of opinion that but for exceptional cases, no deaths will occur if the air pressure is decreased gradually; they propose to allow two minutes for every 0·1 atmosphere in excess of the normal. Their further proposals embrace the provision of a hospital air-lock, where pressures of more than 1·5 atmospheres above the normal are to be used, so that the sick may be treated under pressure, and the housing of the workmen in barracks, so that they may be kept under medical control."

The above recommendations are very similar to those of Dr. M'Kendrick, Professor of Physiology in Glasgow University, who wrote in 1885 with reference to the accidents that had occurred during the construction of the Forth Bridge,*

"Men working under a pressure of two to three atmospheres should not *suddenly* return to the outside air, and arrangements should be made for allowing them to do this gradually, say by having two or more chambers at intermediate pressures. The men should be warned that the danger lies in the suddenness of the act of coming into the open air, more than in working under great pressure. If an accident occur, or if a man feel ill when he comes into the open air, then the right thing to do is at once to return to the place of greater pressure."

The construction of the Glasgow Bridge over the Clyde (1895–1899) afforded further opportunities for observing the effects of working in compressed air, and Mr. B. H. Blythe, M.I.C.E., says:—*

"In sinking the cylinders it was found that up to a pressure of about 30 lbs. per sq. in. men were able to work continuously, that is, eight-hour shifts out of the twenty-four. About that depth discomfort increased very rapidly, and at the extreme pressure of about 43 lbs. or 44 lbs. per sq. in. it was almost impossible for men to work at all."

From the above extracts it will be seen that medical men have given much more attention to the study of the effect of compressed air on the human body than might have been expected, considering the comparatively few opportunities afforded them to investigate the subject. They are not only in accord as to the most suitable treatment that should be used, but they have made suggestions which, when adopted, have been found by actual experience to be efficacious. It can now be said, with confidence, that men can work with immunity in an air pressure up to two atmospheres above the normal if they observe the recommendations above-mentioned, and if the necessary arrangements to prevent illness are made by the contractor.

Accidents caused by Compressed Air.—There have been several very serious accidents caused by the adoption of the pneumatic process. One of the worst occurred during the construction of the Alexander II. Bridge over the Neva, already referred to. The depth of the foundations in this case varied from 74 to 81 ft., there being, in some cases, 60 ft. of water to contend with, and great difficulty was experienced owing to the bad bottom of the river, which consisted of mud, sand, and gravel, resting on blue plastic clay. The air pressure in the caissons was 2½ atmospheres, and although the men worked only three hour shifts, a good deal of illness was experienced. The first accident that happened was due to the sudden subsidence of one of the caissons, which

* Trans. of the Inst. of Engineers and Shipbuilders in Scotland, October, 1885.

* Minutes of Proceedings, Inst.C.E. Vol. cxliv, page 48.

sunk 18 inches, thus causing the wet mud to fill the air chamber. There were, at the time, twenty-eight men working below, and eighteen managed to escape at once, and two were ultimately rescued, but the remainder were smothered between the mud and roof of the caisson. After this accident the work at this pier was stopped for nearly a year. It was not long, however, before a second accident happened at another of the piers, due to one of the air-locks failing and allowing the air to escape; and of the thirty-two workmen who were in the air-chamber at the time, only three were saved.

America also provides a long list of mishaps of a similar nature. During the construction of the Hudson River Tunnel (1890) twenty-three lives were lost, and at the building of the St. Louis Bridge, where the air pressure was slightly over three atmospheres, fourteen men lost their lives while the piers were being sunk, and of the six hundred men employed for compressed air work, no less than one hundred and nineteen were incapacitated in one way or another, although the working hours were reduced to about one per diem.

There can be no doubt that it is largely due to the experience furnished by the unfortunate examples above alluded to that the serious accidents that have occurred in this country in carrying out similar work have been comparatively few.

The Cost of Different Systems Compared.—Engineers have frequently indulged in long discussions, mostly of an academic character, on the comparative cost of foundations constructed by different methods, but, unfortunately, the information at their disposal was not sufficient to warrant much reliance being placed on the accuracy of their conclusions. The preparation of estimates for foundations is, of course, essential, but what the work will actually cost is one of the risks that has to be taken by the contractor. Neither is the experience already gained concerning the expense of carrying out such work of great assistance. It but rarely happens that any two cases are so similar as to allow them being compared, for even if the work to be done is much the same in both instances, the comparison would probably have to be made with the cost of doing it at a time when both the price of the materials required, and the wages of the men, may have been very different. Although this be the case, it is always interesting to study previous examples, since, if they do not indicate the method that should be followed, they often teach us that which should be avoided.

The reconstruction of a viaduct 1,066 ft. long at Shoreham, for the L.B. & S.C. Railway (1893-95), did, however, afford an opportunity of comparing the cost of excavating inside cylinders by grabs, and by divers, and consequently forms an exception to the above remarks.

The viaduct (which carries a double line of railway) is composed of fourteen ordinary plate girder spans, each about 75 ft., carried by cast-iron cylinders sunk from 25 ft. to 40 ft. into the ground, the depth of water which had to be contended with at low tide being only a few feet.

The cylinders were 5 ft. diameter, but that of the bottom lengths was increased by one foot. The material to be excavated was at first gravel, then a mixture of chalk and clay, and, finally, solid chalk. The actual cost of sinking the cylinders by diggers, including all charges for plant, staging, repairs, coal, &c., was 30*s.* per lineal foot, sunk into the ground, the cost of doing similar work by divers being 38*s.* The average rate of sinking was 3 ft. in twenty-four hours. Had the cylinders been of larger diameter the advantage of using diggers would have been still more pronounced.

The cylinders carrying the Caledonian Railway Viaduct over the Clyde (1876–78) were sunk by diggers, the material excavated being mud, clay, and sand. The river cylinders were 15 ft. diameter, and those on land 13 ft., the former being carried down 85 ft. below high water. The depth of the Clyde at this point was only 13 ft. at low water, and the range of tide 10 ft. In this case the

cost per cubic yard of the material excavated was 15*s.* 9*d.* for the land piers and 18*s.* 6*d.* for the river piers.

In the case of the Tower Bridge over the Thames (1886–1894) the pier foundations were also excavated by diggers until the water could be removed, and thus allow navvies to do this work. The total cost of these foundations, including the masonry up to the level of 4 ft. above high water, was £2 3*s.* 7*d.* per cubic yard, and the rate of sinking by the diggers and men averaged 8 ins. and 3 ft. 9 ins. per twenty-four hours respectively.*

On the Continent the cost of foundation work done by the pneumatic process, including the iron caissons, concrete, and the usual proportion of masonry, is generally estimated at £3 per cubic yard.

The Forth Bridge, 1883—1890.—As it is nearly twenty years since the foundations of the Forth Bridge were completed, this work cannot be properly regarded as a recent example of the application of compressed air to sinking caissons. It is desirable, however, to briefly refer to the undertaking because it afforded the opportunity of surmounting many difficulties which attended the introduction of the pneumatic process, and may be regarded as the source from which our experience of such work on a large scale has been obtained. If an additional reason for shortly describing the operations then carried out were necessary, it would be found in the fact that, with the exception of a paper by Mr. A. S. Biggart on the subject† no complete and authoritative account of the work has ever been written.

On the south, or Queensferry side of the river the bridge rests on four piers. The caissons for these are each 70 ft. diameter, and were sunk to depths ranging between 71 ft. and 89 ft. below high water. The bed of the river consists of soft mud, of varying thickness, overlying boulder clay, and it is upon this latter material that the piers are founded. The maximum load on the clay, in the case of the deepest pier, is about 20,000 tons, and consequently the pressure per square foot does not exceed five tons. The central and northern piers of the bridge rest on rock.

The Queensferry caissons, each of which weighed about 470 tons, were formed of iron plates and angles with the exception of the shoes which were of mild steel. They were built on the south bank of the river, and on being completed were launched like a ship, and towed to their required positions. A sufficient quantity of concrete was then laid over the roof of the air chambers, to cause them to sink and rest on the mud, and ensure their stability at all states of the tide. The sinking plant consisted of three shafts 3 ft. 6 in. diameter with their air-locks, two of which were used for the material that could not be ejected, and the other for the workmen to enter and leave the air chamber. Three ejector pipes were also provided for discharging the silt, when such had been rendered, by being mixed with water, of the consistency permitting this operation being carried out. The working chamber was supplied with air from three compressors having steam and air cylinders 16½ in. diameter and 24 in. stroke.

The actual sinking was commenced by a few men opening up a passage to the working chambers by clearing away the mud which had accumulated at the bottom of the air-shafts. The ejectors were then used until the caissons were sunk to the clay, thus making it possible to excavate, in the ordinary manner; and although the rate of progress of the sinking was at first somewhat small, it was afterwards much increased by using the "hydraulic spade" devised for this purpose by Sir William Arrol, the contractor. If the caissons did not descend as the material was removed from beneath them, the men were at first withdrawn from the working chambers, at the time of low-water, and the air pressure slowly reduced. It was soon

* Minutes of Proceedings, Inst.C.E. Vol. cxiii., page 136.

† Trans. of the Inst. of Engineers and Shipbuilders in Scotland, October, 1885.

found, however, that this operation could be carried out with perfect security and that it was therefore unnecessary to take this precaution, so that the progress of the excavation work was not latterly impeded.

The S. W. Caisson was sunk 39 ft. in ninety-nine days and the S.E. 37 ft. in 72 days, but by the use of four hydraulic spades just referred to this rate of sinking was increased to 43 ft. in 72 days at the N.E. Pier. The maximum air pressure while the caissons were in the silt was 27 lbs. per square inch above the normal, and 16 lbs. when the boulder clay had been reached, the rise and fall of the tide amounting to 18 ft., only causing the latter pressure to vary two to three pounds per square inch. As long as the pressure did not exceed eighteen pounds per square inch no illness amongst the workmen occurred although the work was carried on night and day by six hour shifts, Sundays excepted. As the pressure was increased the usual symptoms of sickness appeared, especially when the soil was muddy, but fortunately but very few of the cases were of a serious nature.

The Sterilisation of Water.—Dr. Rideal, writing on this subject in *The Times* "Engineering Supplement," states that it is shown by recent typhoid epidemics such as occurred recently at Lincoln, that neither sand filtration nor selection of sources can give security against infection unless the consumer finally sterilises his drinking water. Distillation is an ideal method, although heating water to 100° C. for fifteen minutes, or boiling it vigorously for five minutes, destroys all organisms except very resistant spores. On a large scale in commercial sterilisers steam is commonly used, applied in one or other of the following ways: (1) Closed steam coils. (2) Forcing steam into the water itself. (3) Generating the steam from the water itself in the same vessel, and arranging coils for causing the liberated steam to heat the incoming water so as to make the apparatus regenerative. The results obtained by Dr. Rideal with different sterilisers show that sterilised water can usually be ensured. Non-pressure forms, however, do not effect the destruction of spores, but this fault does not militate against their use as a protection against cholera and typhoid.

The Prevention of Coast Erosion.

By Dr. J. S. OWENS, B.A., A.M.Inst.C.E., F.R.G.S.

In my previous articles on "Coast Erosion" the agencies and forces at work were briefly considered. The present series will, therefore, be devoted to a short study of remedial measures. At the outset of such a consideration as this it will occur to many that it is useless for us puny mortals to array ourselves against the mighty forces of the ocean, and that no efforts of ours will avail to check the steady advance of the sea where it is encroaching upon the land. Some will say at once the land is sinking, and consequently encroachment is inevitable, and no doubt in places this is so. A careful study of our whole coast line supplies ample evidence that the action of the sea in degrading and carrying away material from the land is more effective than any action t may have of an accumulative or building up nature. Although in many places thousands of acres of good land have been reclaimed and saved from the sea, there is no doubt that on the whole more material is carried away than is brought back.

It is true, however, that the greatest amount of material is derived from the erosion of high cliffs, whereas the land cast up by the sea is always low and flat, so that the actual amount of land surface may remain practically constant. However this may be, for the present consideration we may divide up our coast into three divisions. First, where erosion is going on steadily, and the sea is encroaching upon the land. Second, where deposition exceeds erosion, and the result is a steady growth of the land seaward. Third, when neither erosion nor accumulation is obvious, they cannot be absent but may balance each other.

Curiously enough, in the second of these divisions, where land is being reclaimed from the sea, sea-defences are of as great importance as in the first, where erosion is going on. Such land, being usually below the level of high

water, and protected from inundation by embankments, calls for careful attention to such embankments, as although safe from ordinary erosion, they may, and often do, suffer from occasional attacks due to exceptional conditions of wind or sea. Although this new land may be deposited in the first instance at about the level of high water of spring tides, it must be remembered that when enclosed by embankments a process of desiccation and lowering of the surface level goes on, as the ground gives up its surplus moisture by evaporation, drainage, &c., so that it soon becomes liable to flooding, not only by extraordinary tides, but by any ordinary spring tides. There is, however, usually little difficulty in such cases in obtaining adequate protection, since the tendency of the sea is to recede, and it is only against occasional attacks that such protection is needed; assuming, of course, that a proper embankment has been erected in the first place. Here, then, is a very important point which meets us at the outset when considering any particular shore: Are we dealing with a case of true, steady erosion where the sea is gradually but surely encroaching upon the land? Or is it only the result of an occasional attack due to exceptional conditions, upon a shore where the natural tendency of the sea is to recede?

It will be clear that the remedy which in the one case might be quite capable of coping with the difficulty, in the other may only be a source of expense and disappointment. It is obvious, therefore, that no such general assertion as that which is often heard relative to the uselessness of attempting to battle with the forces of the mighty deep, should be made until we have first made a careful study of the peculiar conditions holding good in any particular case. Even in cases of steady erosion experience has amply shown that much good can be done by judiciously-applied sea-defences. Not, however, by attempting to subdue the mighty forces which are at work, but by a proper application of our knowledge of the action of such forces, which permits us to so humour them, if I may use the word in this connection, that they will even employ their energy in building up instead of pulling down. That this can be done is shown by the wonderful results attained by the application of the late Mr. E. Case's system of low groynes and recent modifications of the same.

Broadly speaking, sea defences may be considered as falling under one of two heads. In the one group the chief aim is to increase the resisting power of the natural barrier or cliff against the sea by substituting a harder and more durable material for that already existing, or by increasing the size and height of the natural barrier, thus providing a greater factor of safety.

Sea-walls, embankments, breastworks, &c., which are merely "passive resisters," are examples belonging to this division. There is, however, another type of sea-defence which attacks the problem from a totally different point, striking at the root of the evil, and attempting to remove the actual cause of erosion, or failing this, to so alter the balance of forces acting upon the shore that the accumulative action will counterbalance the erosive. In the former or passive type of defence there is little room for the exercise of ingenuity, except, indeed, in trying to get even the advantage of the passive resistance without at the same time introducing some new factor which exercises a deleterious influence. That such a factor may be introduced is too often shown in the case of sea-walls, the injurious effect of the rebound of the wave from the face of the wall is notorious, and often so serious as to more than outweigh any good effect the wall may have. Much discussion and differences of opinion have, therefore, always centered round the question of the best form of wall for coast protection.

In the second group, which I may call the active type of defence, there is much more ground for hope, but as the question of causes has always been

somewhat obscure and neglected, it is not surprising that there exists great differences of opinion as to the best form of defence.

Some very remarkable remedies have been proposed. The following extract from an essay* written in 1844 is perhaps one of the most curious suggestions yet made: The author suggests that "long tined harrows be fastened to the stern of a boat, which, being urged by men, will loosen the material on the surface of a shoal, and the flowing water will carry this . . . towards the shore." He also says further on that "a plough might be employed with considerable advantage, turning the furrows towards the cliff."

Many patents have been taken out in this country for devices of various kinds to check erosion. Floating breakwaters anchored to the bottom, and wave-screens, formed in strange and wonderful ways, occupied much attention at one time, the idea in both cases being to destroy the waves before they reached the shore. These methods, however, met with little success, the waves in most instances doing the destroying. It was proposed by Martin to place tanks filled with oil along the foreshore, which could thus be distributed over the surface in rough weather to calm the troubled waters.

These may all be considered as attempts to reduce the violence of the attack.

Shore protection works may be divided, as shown above, into active and passive types: the former comprising groynes and such structures as attempt to do something more than merely resist attack; the latter including sea-walls, &c., which only attempt to substitute a harder and more durable material for a softer.

All efforts to combat the evil by reducing the violence of the attack have, in practically every case, resulted in failure. The forces we are dealing with are on too stupendous a scale to succumb easily to man's puny efforts. There is no doubt that an efficient wave screen, if it could be erected, would give the very best protection, but all attempts to do this at a reasonable cost have been failures. The only really efficient wave screens which now exist are the piers and breakwaters protecting our harbours, but such structures as these are obviously out of the question for coast protection.

That light wave screens were not a success is not to be wondered at, when the enormous force of wave impact is considered, amounting as it does sometimes to three or four tons per sq. foot.

It must also be remembered, that although a permeable screen may be erected and one which if it remained permeable would be efficient, the spaces in the screen soon become choked by growths of weed, and the resistance opposed to the waves and currents so increased that the structure collapses under the strain.

Rocks have been thrown into the sea a little outside of low-water mark and in a line roughly parallel to the shore, with the intention of protecting it from heavy waves, but the result attained has not been such as was anticipated.

Fig. 1, a photograph of Preston Beach, near Weymouth, shows a case where this method was tried. Heavy rocks weighing several tons each were deposited from barges in a line just outside low-water mark. The effect here appeared to be to produce such a disturbance and swirling of the water between the stones that the bottom was scoured away, the rocks sank considerably into the sand and erosion went on much as before. These rocks finally had to be removed by blasting, and when the bottom was cleared, and low groynes run out across the site of the rocks, accumulation immediately commenced and has continued steadily, the erosion being checked.

When it is remembered that fine matter such as sand will not be thrown out of suspension in water which is a mass of eddies, the importance of avoiding unnecessary disturbance of the water by artificial means becomes obvious.

* Essay on the encroachment of the German Ocean along the Norfolk coast.—W. Hewitt, 1844.

The protection of foreshores by means of groynes is of very ancient origin, dating back certainly to the seventeenth century. But strange to say until quite recent years very little, if any, advance appears to have been made in the method of applying them.

Let us consider in what way a groyne can act so as to cause the accumulation of material upon a foreshore. It is clear that the material which is brought by the water must either be in suspension or moved along the bottom.

To trap the latter appears to have been the sole idea in erecting groynes up till late years, but the quantity of material which is thus transported by the water along the bottom is very small indeed when compared with the finer material which is capable of being churned up into suspension. It should therefore be our object to try to collect the latter as well as the former.

It may here be noticed that while almost any obstruction will suffice to check the travel of shingle, the same is not true for sand. If, therefore, we erect a groyne suitable for catching sand we may be satisfied that it will also catch and retain the shingle, if any is there, but the converse of this is by no means true. For instance, if a groyne be erected, the top of which is above high-water mark, thus completely diverting the littoral currents, it is clear that not only can these currents bring little to the groyne, but the diversion being altogether round the seaward end is sure to cause considerable scour there. What we must aim at is, therefore, not a complete and entire stoppage of the littoral or along-shore currents, but some means

FIG. 1.—VIEW OF PRESTON BEACH, SHOWING THE ROCKS DEPOSITED BEYOND LOW WATER MARK FOR PROTECTION. THE LOW GROYNES ARE ALSO SHOWN; THESE WERE SUBSEQUENTLY RUN OUT ACROSS THE SITE OF THE ROCK.

by which such currents will be permitted to flow over the foreshore, bearing their burden of suspended sand, and by which this sand can be thrown out of suspension in the proper place.

If we erect groynes we must therefore be careful not to completely intercept the currents, but to keep the groynes of such a height, that while slowing down the lower layer of water sufficiently to throw the sand out of suspension, the upper layers of the current are permitted to flow over the tops of the groynes, bearing the sand along and gradually losing it as the grains sink into the lower and more slowly moving parts of the current nearer the shore surface.

It may broadly be said, that the direction of sand drift is controlled by the prevailing currents whether produced by wind or tide, whereas that of shingle drift is chiefly controlled by the direction of the prevailing winds, since the slow currents usually existing along the coast are incapable of moving shingle by themselves; but it is easily shifted by the impact of the waves, the direction of the latter being of course usually governed by that of the wind.

The rougher the sea is, the greater the amount of sand thrown into suspension, and therefore the greater is the chance of the groynes to intercept it. That the currents near the coast are usually roughly parallel to the shore line is a fortunate circumstance, the tendency being to merely transport material from one part of the coast to another, and so circulate it round the coast. It is only under exceptional circumstances that a current can set towards or away from the shore, but when it does, no form of sea defence yet devised will prevent such a current from causing erosion if setting seaward along the bottom. Groynes are ineffective where such currents flow, so that we may really consider the whole coast line as having a certain amount of material, sometimes one part loses and another gains, but on the whole there is a loss. There is little doubt that when all the movements of the water are considered, there is a preponderance of seaward drift of material over landward; we may at once put this down to the invariable existence of a gradient seaward.

Seeing then that our object is to try and intercept the drift of material we must see that we do not introduce any new factor which may stultify all our efforts. For instance, I know of places where groynes have been erected, very good groynes in most respects and quite suitable for the places, but throughout the whole length of the groynes the bottom edge of the planking is several inches above the level of the foreshore. Consider the result of this; the currents flowing along shore strike the groynes, and the sectional area through which they have to pass being reduced by the planking, they are diverted both over and under the groynes, at a higher velocity than the normal, with the result that the shore is scoured away directly under the groynes, and more harm than good is done. It is of the utmost importance, therefore, that no under-run be permitted to form beneath a groyne, therefore it is practically always necessary to sink the planking well below the surface of the shore. This, of course, refers to timber groynes. In masonry groynes it is even more essential to get the foundation well below the possible limits of scour.

Partly to remedy this danger, I have designed a groyne, a detailed description of which will be given further on, in which, instead of planking fixed to the piles, reinforced concrete slabs are used, sliding in grooves moulded in reinforced concrete piles, their own weight making them self-adjusting to such under-runs.

There is, I believe, another danger which may arise through having groynes placed too closely together. When a current strikes an obstacle, such as a groyne which does not completely intercept it, a series of eddies are set up in the current by the obstacle. The current flowing against the groyne is deflected upwards by it, and striking the layers which are flowing above the top of the groyne, it bends round on the other side in the form of a swirl or eddy,

lying along under the lee of the obstruction.

There is some reason to believe that the disturbance produced by this swirl extends to a considerable distance on the other side of the groyne before it dies away; but as long as the disturbance exists to any extent it may interfere with the deposition of material.

I cannot say to what distance it extends, as this would no doubt depend upon the velocity of current, height of groyne, and depth of the water. If, however, another groyne is met with by the water before the disturbance has died away, the result is probably to reduce the chances of deposition. In support of this, I may say that at Dymchurch, where Mr. Case first tried his low groynes, the sand accumulated between them was distinctly higher in the middle of the space between two groynes than alongside either; the highest point being that of maximum deposition, and probably indicating the termination of the disturbance due to the groyne. I think, therefore, that the distance apart of groynes should depend to some extent upon their height, and that it is possible to have them so close together as to be positively injurious. It is usual to make the distance apart about equal to the length of the groyne, *i.e.*, from high-water mark to low-water mark, but this rule is founded only on experience.

I hope at a future time to investigate this question experimentally, as I feel certain something better than mere rule of thumb should guide us in a matter of such importance.

As to the length of groyne, there is little question; they should undoubtedly be extended not only to, but beyond low-water mark where possible to do so. As long as we were content to collect shingle only, and gave no thought to collecting the finer material, groynes were in nearly all cases heavy, substantial structures, extending from well above high-water mark to about mean sea level, this being the zone of the foreshore on which the greatest movement of shingle takes place; but of late years, since the late Mr. E. Case showed that groynes were capable of a much more extended use, and that valuable shore-building material could be taken from the water in the lower part of the foreshore, there has been a great change in the practice. He also showed the great value of properly-designed groynes in removing swills and bars from a shore and converting it into a smooth stretch of hard sand.

Sometimes, owing to various causes, long lake-like swills form on the foreshore, disfiguring it, and making it not only unpleasant to walk over but very dangerous. By extending low groynes across these swills, it was found possible to fill them up. Under ordinary circumstances, when the waves were breaking upon the bar seaward of such a swill, each wave rushed over the bar and into the swill carrying its burden of sand, but having got into the swill, the water could not return back the same way, but had to flow along the foreshore like a river, to some point where it emptied into the sea, the result being that the swill was constantly kept open by the current. Now when the groynes were extended across it, this current was checked on the bottom, and the sand washed over by the waves quickly filled the channel up. These swills often give rise to accidents, since the tide when flowing fills them up before the sand seaward is covered, thus sometimes entrapping children, who whilst playing on the sand do not notice the tide coming in behind.

It is clear, that for the purpose of collecting shingle, the groynes need only be extended across that zone of the foreshore where the shingle moves; but to collect sand, groynes should extend across the whole zone where sand is in movement, and this is from high-water mark to some distance beyond low-water mark.

The success of groynes extending beyond low-water mark in collecting material has now been amply proved. In fact, the part of the sea bed immediately beyond low-water mark has

probably more movement of material going on in it than any other part, owing to the breaking waves at low water, the length of time the tide hangs about this point, and the fact that when covered by the water it is still exposed to the action of currents and waves. Thus we have here a part exposed to the agencies which move material for a longer period than any other part of the shore. It is, therefore, most likely that if groynes do any good at all, here is the place where they should produce the greatest effect. Many attempts have been made to devise a form of construction suitable for this part of the shore, but on the whole with little success up till late years. For instance, in 1890, Thompson patented a structure which might be called a submerged groyne, composed of submerged fences or permeable barriers of twisted willow fixed to wire ropes anchored to the bottom; the idea being that these should impede the along-shore currents and so become efficient as groynes. Such designs are of interest as showing the attempts which have been made to check erosion about or beyond low-water mark. But it would be obviously difficult, if not impossible, to keep such structures as the above in position during a severe gale.

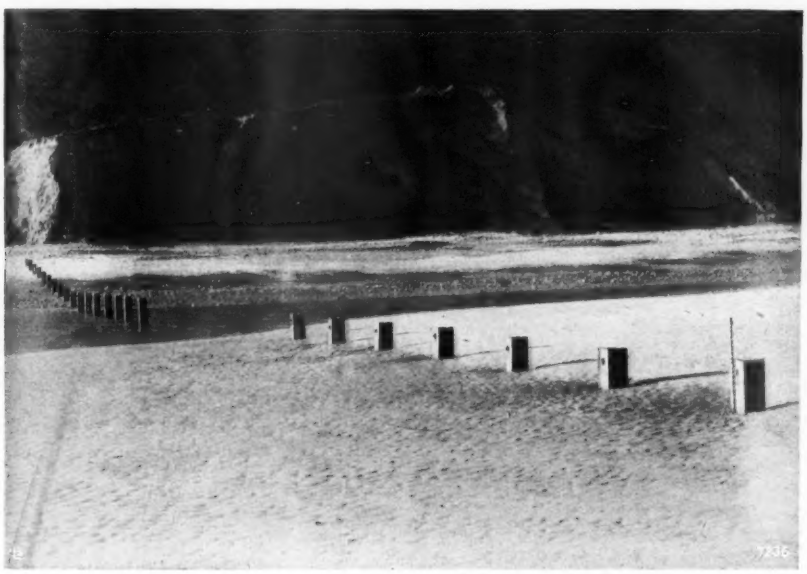


FIG. 2.—SHOWING A SWILL WITH A "CASE" GROYNE BEING RUN ACROSS IT. NOTE THE BAR OF SAND ON THE SEAWARD SIDE OF SWILL.

Any extension beyond low-water mark should, in my opinion, be capable of easy adjustment to the level of the surface as accumulation takes place. If put in too high at first evil results, hence it is necessary to commence low, say not more than two or three feet above the surface of the sand, and gradually increase the height as required. There is thus less probability of scour, and a lighter structure may be used.

The way in which a groyne terminates

also influences its effect upon the bottom, and this is true for both the landward and seaward ends. Since it has been shown by experience that when a groyne terminates abruptly at some height above the surface there is a great tendency to scour around the end, owing no doubt to the diversion of the currents; at the seaward end a groyne should therefore terminate by a gradual lowering of the top, either in steps or otherwise, to the level of the shore; and at the landward end it should die out into the shore, unless it ends in a sea wall or is brought well above high-water mark, in neither of which cases can the currents or waves get round the end.

The cause of this tendency to scour around the abrupt termination of a groyne or any other obstruction thrust out across the direction of a current, will be clear when it is remembered that a great part of the current is directed by the obstruction from its original path. If the groyne be high enough, the diversion must take place round the end. Now there is already a current flowing past the end, and this together with the inertia of the mass of water beyond the end, results in a tendency for the diverted water to pile up on itself, raising the surface level until sufficient head is produced to drive the water round the end of the groyne, at a much higher velocity than the normal, since the space is restricted by the above causes. Hence the necessity for both keeping the groyne low, so as to direct the water over the top instead of round the ends, and for a gradual dying out of the groyne into the shore level, so as not to locate the scour to one spot, and so concentrate it. This holds good also in the case of the localised current due to breaking waves, the effect being the

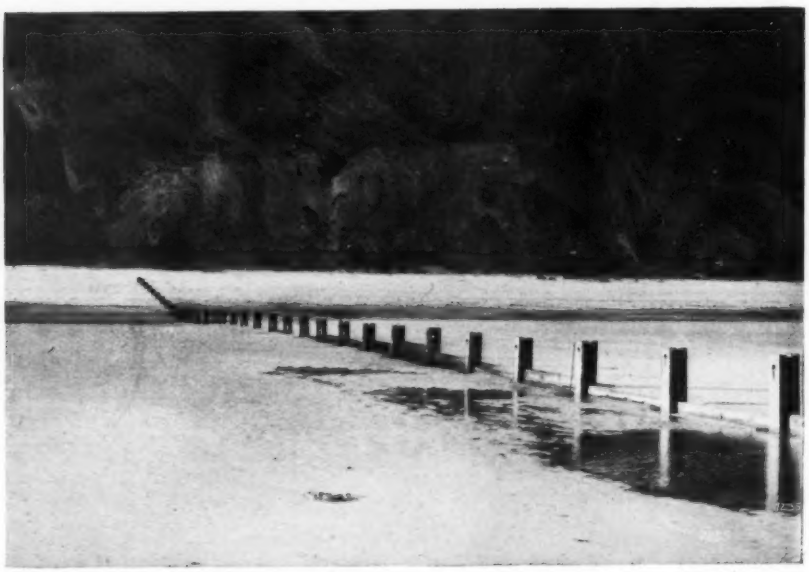


FIG. 3.—SHOWING THE SAME GROYNE COMPLETED AND ONE MONTH AFTER CROSSING SWILL. THE BAR HAS BEEN MOVED LANDWARD INTO THE SWILL.

same though intermittent, and only apparent when the waves strike obliquely.

It has sometimes been said that it is useless to erect groynes upon a foreshore where there is no material to collect, but it must not be forgotten that the function of groynes is not solely to collect material. They have a very beneficial action in some cases, in merely checking erosion, and holding the material already upon the foreshore, prevented. The fact that the slightest disturbance of the water lifts such fine particles into suspension, and so transports them instead of dragging them over each other along the bottom, helps to limit the amount of grinding to which they are subjected. It has been shown by experiment that a very slight current of water passing upwards through sand converts the whole mass into practically a fluid state, each particle floating in the

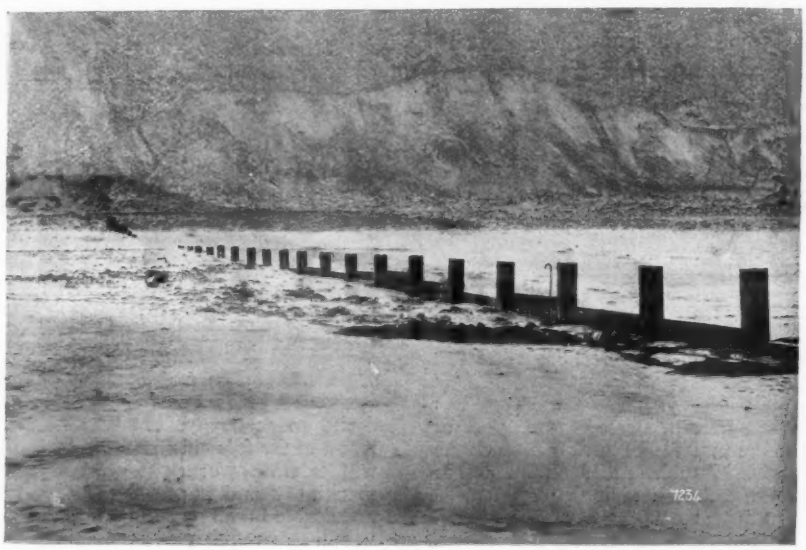


FIG. 4.—SHOWING THE SAME GROYNE A LITTLE LATER, AND A FURTHER SILTING UP NEAR LANDWARD END OF THE GROYNE.

which would otherwise be carried away. Groynes can never be expected to completely prevent erosion in such a case as this, for there is always a grinding down action going on between the particles of shingle producing an impalpable mud which floats away in the water. But this is a slow process, and appears almost to cease entirely when the particles reach a certain degree of fineness, in which state they are separated from actual contact with each other by a film of water, and further degradation thus water. This is very obvious when the small amount of water necessary to sink piles by means of the water-jet method is considered. Much discussion has turned upon the direction which groynes should take relative to the shore line, some holding that they should be placed at right angles and some that they should be directed towards or away from the prevailing wind. On an old chart of Dover Harbour in the Cottonian Collection of manuscripts in the British Museum, and dating about 1600, there

are several groynes shown, some being at right angles and some oblique to the shore line, the oblique groynes being inclined towards the west, and therefore towards the prevailing wind. I cannot see any good reason for departing from the right angle direction, the efficiency of a groyne depends upon its ability to intercept drift, which is another way of saying that it depends upon, amongst other things, its length, *i.e.*, upon the distance to which it extends across the littoral currents. It is obvious that for a current flowing parallel to the coast line any departure from the right angle direction means a reduction of efficiency for a given length of groyne. I do not mean to say that a groyne directed obliquely to the shore will not do efficient work, but simply that a shorter groyne directed at right angles to the shore line will do the same work. If the direction of a groyne is very oblique, the effect must be positively injurious, for not only is there more surface exposed to the wave stroke, and a consequently greater liability to scour from the rebound of the waves from the groyne, but also water flowing down the foreshore from the back-wash of the waves is intercepted by the oblique groyne, which thus produces a serious current located to one part of the shore; instead of having the volume of the backwash spread out in a thin layer over the shore it is concentrated along the groyne, producing a deep channel down which the sand is swept. The direction in which waves strike a shore is not constant, sometimes they come from one point, sometimes from another, so that it is impossible to base our calculation upon that. Even when the "prevalent" wind can be calculated on, the direction from which the most damaging storms come is not always that of the prevalent wind. So that on the whole the best direction for a groyne under ordinary circumstances is at right angles to the shore line.

In my next article I will consider briefly the materials used in the construction of sea defences, and go on to a description of the various types of groynes which have been used.

The Design of Engineering Workshops—I.

By H. MUNCASTER.

THERE are many workshops which, although equipped with modern plant and labour-saving devices of various sorts, are far from being satisfactory on account of the unsuitability of the buildings. These have been extended at various times, bit by bit, as more accommodation has been demanded by increased business, and although the capacity has been increased, the efficiency and convenience has not been correspondingly maintained. For, as it is seldom practicable or even possible to pull down and rebuild a shop on a larger scale during the time that business is brisk, it is usual to add to the existing buildings such extensions as may at the time meet the requirements and can be readily undertaken at the period.

We are sometimes said to be very conservative in workshop practice. To some extent this may be true, but our conservatism is generally due to our desire to economise plant, and is the result of the false idea of economy which will tolerate worn out and obsolete machinery and appliances, as well as unsuitable buildings, badly lighted and ventilated, requiring an excessive staff to maintain a thorough supervision, making it difficult to produce work of a high grade, and impossible to attain a satisfactory degree of economy.

To design and equip a thoroughly good and efficient engineering works is a task that demands a range of knowledge and experience rarely combined in one person. Among the many qualifications necessary are an intimate knowledge of building construction in steel, iron, stone and brick, including all details of lighting, heating and ventilation; some practical acquaintance with cranes, travellers, steam, hydraulic, and electrical lifting appliances, mill gearing driving arrangements, steam and electric

motors. He must understand the requirements of the foundry, the working of cupolas, stoves, gas producers, furnaces, the wants of the smith, the boilermaker, the patternmaker. Only a small proportion of such work comes within the sphere of the architect, and very little more within the scope of the mechanical engineer.

The object of these papers is to supply such information as will assist those who may be engaged in the construction of new works, or the extension of existing works, to carry out the requirements necessary for the production of efficient and convenient workshops.

The Choice of Site.—It is not always that the question of site is to be considered, it being often settled by some special consideration; but where the matter is debatable several points demand attention.

(*a*) Connection by road, rail, or water.

In every case where goods or machinery of any considerable weight have to be dealt with it is almost imperative that a railway siding run into the works. The cost of conveying heavy loads by horse and lorry, if only over a short distance is a very heavy item, and except there are other special advantages, it will be good policy to decline a site where connection by rail is not possible. A river frontage may be valuable as a means of shipping goods, either directly into a vessel, or by the use of barges and lighters to convey goods to some convenient place for shipment. If in a like manner goods can be easily transferred to the railway, this advantage may be a set-off against the absence of a railway siding on the site.

(*b*) The surface should be fairly level. That the site should have a river frontage implies that it is fairly low. If the ground is swampy or if a good foundation is not likely to be met with at a reasonable depth it should be avoided. The foundry especially should be placed on ground that is free from water, and where there is no risk of the place being flooded during fresh weather. In many cases it is possible to improve the site by levelling, and in setting out new works allowance should be made for utilising on the site the materials excavated from the foundation of the walls, columns, &c., also from the erecting pits, moulding pits, furnaces, chimney bases, underground flues, pipe trenches, &c. There will be a continuous accumulation of slag, cinders and refuse from the various departments which may for a time be found useful for filling up the hollows and generally improving the site. This is a point that may be taken as a double advantage as the disposal of refuse may otherwise have to be paid for and prove expensive.

(*c*) There should be a fair prospect of suitable accommodation available for the workmen at a convenient distance and at reasonable rates.

To a great extent the cost of house rent affects the cost of labour, especially in the lower ranks where the rate of pay is usually the "lowest living wage." It is coming to be recognised more generally that the domestic environments of a man exercise some influence on his work, and that a thoughtful steady workman does not appreciate squalid surroundings. If they do not suit him he goes elsewhere, so that to neglect his interests in this direction means the loss of the most desirable class of workman.

Building Materials.—The selection of the most suitable materials for the buildings will be to a great extent controlled by local conditions. In some parts stone will be found of a quality sufficiently good for all building purposes, and, if cheaper than brick, may be used to advantage. In appearance, when properly built, it is preferable to brick. The latter has some advantages over stone where it can be had at a cheap rate and of good quality, being capable of more expeditious handling than stone, and on account of the more perfect "band" attainable, walls can be built of brick safely, with much less material than would be practicable if built of stone.

During the last few years a great

change has taken place in the character of buildings erected for workshops. The use of rolled steel bars has become general, having taken the place of wood in roof-trusses, floor-beams, astragals for glazing, &c.; they are now used in place of cast iron for columns, stancheons, brackets, &c. A building composed of this material can be erected in a very short time, and, if properly designed, is light, and can be completed at a comparatively low cost.

Corrugated galvanized iron and steel sheets are largely employed for roofing and covering the sides of such a building, but is not by any means a suitable or economical material for this purpose. True, the first cost is low, but the sheets require frequent painting or covering with some non-corrosive composition, and will, in spite of this, require renewing entirely every six or seven years. There is the further difficulty that the air in a building covered with these sheets is most difficult to keep at an even temperature. In bright sunshine the sheets get hot and the atmosphere becomes oppressive, while in cold weather the cost of maintaining a suitable temperature is excessive. For these reasons sheet iron or steel should not be used to any great extent for the purpose mentioned. Sometimes the exterior walls are carried up to a height only of, say, seven to fifteen feet, above which sheeting is used supported on a light steel framework.

In place of sheeting, slates nailed to boarding are recommended for roof-covering. The first cost will be about twice that of sheeting, but as slates will outlast many resheetings there can be no doubt as to the ultimate economy of using slates.

Span of Buildings.—Buildings of considerable width are generally divided by rows of columns supporting the roof into bays of moderate span. A building 100 ft. wide might be divided into two bays of 50 ft. or into three bays of 33⅓ ft. span. When the demand is simply for covered space, in which columns are likely to interfere with the work, the adoption of large spans is desirable; but as this is not generally the case in engineering shops, spans of moderate dimensions are better suited to the conditions. In a machine shop it is necessary to make provision for the carrying of lines of shafting, also for the support of counter-shafting and overhead gear for operating the machines. The roof

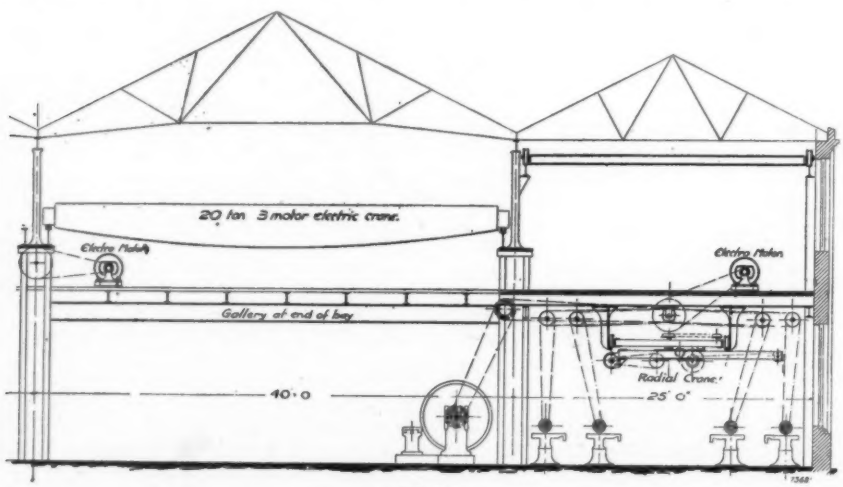


FIG. 1.

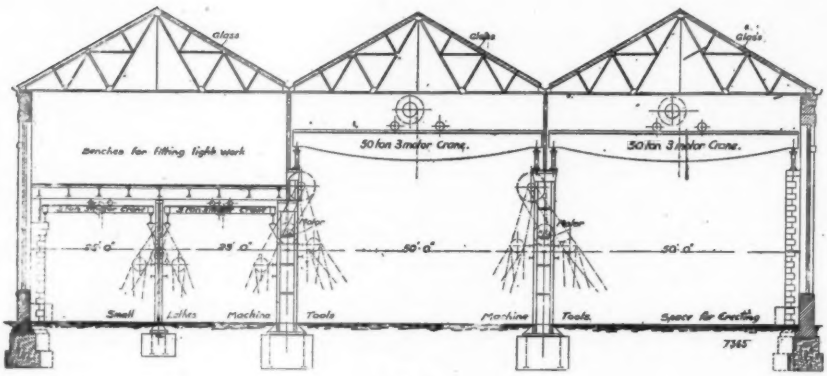


FIG. 2.

columns offer a suitable means, and are generally utilised for this purpose. From practical considerations it is found that the maximum distance a machine tool can be conveniently driven by a belt is about 15 feet in a horizontal direction, so that the width of a machine shop seems to be limited to a span of 40 ft. centres of column. It must also be remembered that the cost of large spans is greater than the cost of moderate spans for the same area covered. Another point is that travelling cranes are proportionately heavier for the same duty, and are not so handy, besides consuming more power in moving about.

As an illustration in favour of spans of moderate dimensions, we are kindly permitted by Messrs. Kendal and Gent, of Manchester, to publish a cross section of their machine shop. The shop is divided into two bays of 40 ft. span and two bays of 25 ft. span. Both of the 25 ft. bays have a gallery extending the full length of the bays. The arrangement of main driving and countershafting is extremely neat and convenient. The hangers carrying the shafting are attached to the joists of the gallery-floor, as also are the rails, on which runs an ingenious electric jib crane. This crane can serve any of the lathes and machines without fouling any of the belting-drives. The two central bays are used for the heavier classes of work. The large lathes and machines are arranged near the side columns, the middle of the bays being reserved for the fitting and erection of machine tools. The outer walls are of brick. Fig. 1 is a section of one 40 ft. and one 25 ft. bay.

A further example is given in Fig. 2, which is a section of a machine shop having three bays of 50 ft. span, centre to centre of columns, one bay having a gallery 20 ft. above the ground-floor. This shop is intended for the heaviest class of marine engine work. The two open bays are served by electric travelling cranes, some with a capacity of 50 tons, the small bays with cranes up to 3 tons. The walls are of stone 2 ft. 3 in. thick. The whole of the northern slopes of the roofs are glazed with $\frac{1}{4}$-in. glass. Large windows are built into the walls, and serve to light the space under the gallery.

Departments.—Engineering works may generally be divided into six departments, for which separate buildings are required, as under :

1. Machine and fitting shop.

It is found most convenient to arrange the fitting and erecting shop as a continuation of the machine shop, especially where heavy machinery is to be handled.

2. Iron foundry.
3. Boiler makers' shop.

Where riveted work, such as girders,

bridges, or roofing, is undertaken, in addition to boiler making, it may be done in connection with this department, some of the machine tools being available for either class of work.

4. Smithy and forge.

5. Brass foundry.

Where very heavy bronze castings are to be made, as, for instance, ships' propellers, stern-posts, or rudder-frames, the ordinary equipment of the brass foundry will be insufficient, principally on account of the inferior crane power. It is advisable in such a case to utilise a space in the iron foundry to make these castings where the room is ample and the crane power suitable. It will be necessary to build a reverberatory melting furnace of the requisite size just outside the foundry wall, with a spout to enable the molten metal to be run into the foundry.

6. Brass-finishing shop.

It is desirable to keep the brass work separate from the iron and steel work, mostly so because of the value of the metal removed by the machine, which is returned to the foundry.

In connection with the machine shop a separate department is equipped for tool fettling. This is an important branch, and should be fitted for repairing and keeping in order all classes of cutting tools.

It is of importance that there should be a considerable amount of yard space, where can be erected bins, &c., for pig-iron, limestone, coke, coal, iron and steel plates and bars, timber for pattern-makers, sand and loam, also space for moulding boxes and old patterns.

In addition to the buildings enumerated above, will be the power station for the supply of electric and hydraulic power to the various shops.

Fig. 3 shows in plan the general arrangement of an engineering works employing about a thousand hands and turning out engines, boilers, millwright and structural work.

For the proportionate sizes of the various departments no exact rule can be given, so much depending on the class of work to be done. Some idea, however, may be obtained from a consideration of the dimensions of existing workshops. The table on top of next page has been prepared from actual practice in works, where the distribution of space to the various shops has been fairly satisfactory, with a view of giving approximately the sizes of the various departments.

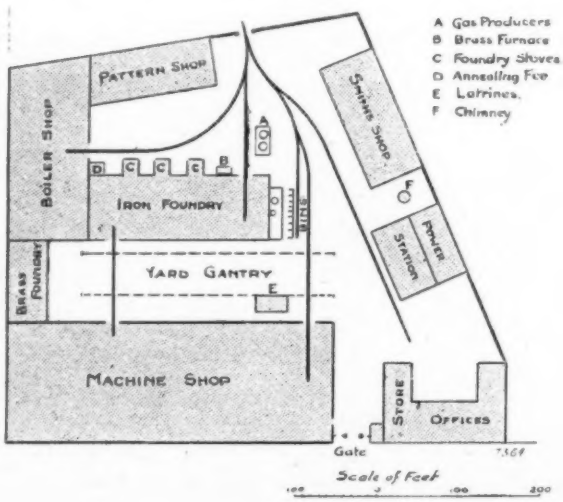


FIG. 3.

Column A. gives the area in superficial feet of the various departments of an engineering works almost solely occupied in the manufacture of marine engine, and of heavy-gun carriages and mountings.

Columns B. and C. of general engineering works making engines, boilers, millgearing, &c.

Column D of a small locomotive works.

Column E. of a works employed almost exclusively in the manufacture of machine tools.

The Iron Foundry.—The general features of the examples given in Figs. 4 and 5 will be readily understood. The total length of the building

I.

	A.	B.	C.	D.	E.
Machine and fitting shop ...	350,000	90,000	25,000	31,000	12,000
Boiler shop	150,000	40,000	16,000	15,000	
Iron foundry	39,000	40,000	9,000	5,000	6,000
Smithy	16,000	12,000	5,000	5,000	3,000
Brass foundry	18,000	6,400	800	1,500	1,000
Pattern shop	18,000	13,000	3,600	2,100	2,100
Brass finishing shop	10,000	8,000	1,600	machine sh.*	machine sh.*
Tool fettling	8,000	3,600	not separate	1,600	not separate

* Contraction of Machine Shop.

is 220 ft., and the width in two spans is 80 ft. The larger span of 50 ft. is 40 feet high to eaves, and is supported on columns formed of one 16 in. by 6 in., and two 12 in. by 6 in. rolled steel **H** joists with suitable gussets, cap and base plates. The columns are 22 ft. apart, and support a gantry girder of the double web type 3 ft. in depth calculated for a 30 ton travelling crane. The smaller span of 30 ft. is supported on columns of simple 12 in. by 6 in. **H** bars.

The whole of the columns are erected on concrete blocks. After the steel work is erected and properly adjusted, and the base of the columns grouted, a dwarf wall of brick is built round as shown, leaving the necessary openings for doors, drying stoves, and windows (if desired). The space between the top of the wall and the eaves is covered in by sheeting supported on a steel angle framing attached to the columns. In the roof a principal occurs at each pair of columns, also a principal midway which is supported by a rolled steel **H** joist 14 in. by 6 in. fixed to the top of the columns.

The lifting equipment consists of two-

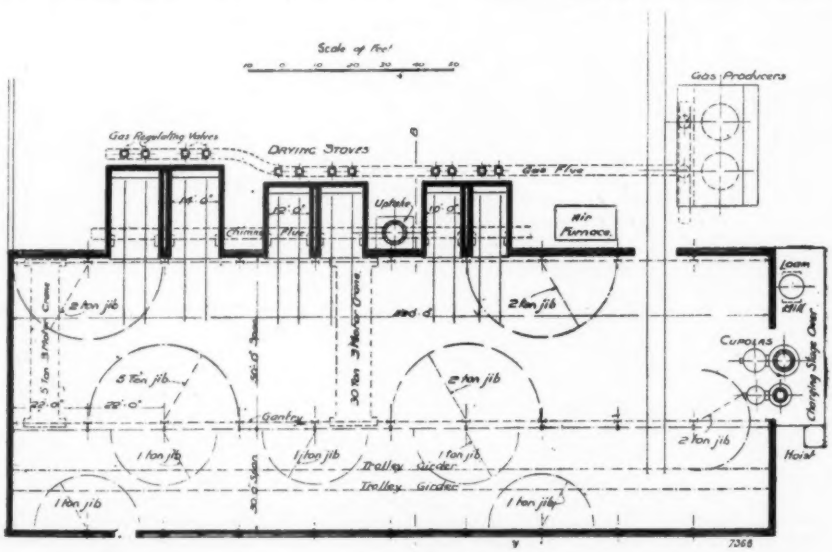


FIG. 4.

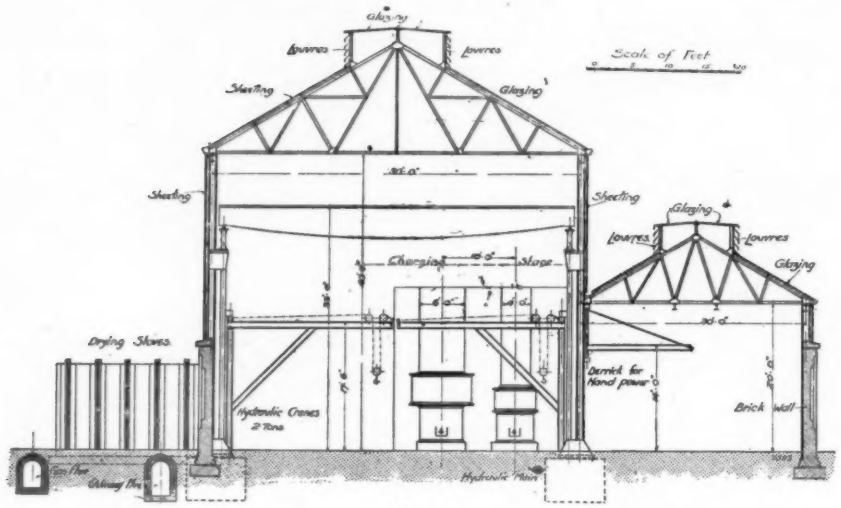


FIG. 5.

three-motor travelling cranes, one to lift thirty tons, the other to lift five tons. Also five hydraulic jib cranes, one of five tons and four of two tons capacity. In the smaller bay there are five jibs, each to carry a block and tackle for any load up to one ton.

In addition there are two lines of girders hanging from the roof truss in the smaller bay. These girders are 10 in. by 5 in., and about 25 lbs. per foot steel H bars, and are so arranged that a small four-wheeled trolley runs on the bottom flange. To the trolley is hung a chain block suitable for carrying a load of say two to three tons.

Against the side of the larger bay the stoves (six in number) are built, varying in size from 14 ft. wide by 25 ft. long to 10 ft. wide by 20 ft. long.

The cupolas are placed at the end of the large bay so that the molten metal can be easily dealt with in heavy castings by the electric travellers. At this end outside the building the bins for the storage of coke, limestone, pig iron, clay, ganister, loam, &c. will be arranged in a position convenient for unloading the railway trucks, and to be handy for the cupolas.

The gas producers, two in number, are placed so as to be near the stoves, and alongside the railway sidings.

An amount of yard space equal to the area of the foundry should be reserved for the storage of moulding boxes and other etceteras in constant use. It is a good policy to erect a light gantry crane over this space to facilitate the handling of anything to be conveyed to or from the foundry, otherwise a great proportion of the space will be unavailable except for very light pieces that can be lifted by hand.

This foundry is in harmony with the general plan of works given above.

(To be continued.)

The Edison Coal Storage Plant.

By OUR SPECIAL CORRESPONDENT.

THE handling and storing of coal at the Shadyside, New Jersey, plant of the New York Edison Co. is of more than passing interest. The Dodge Coal Storage Co., of Philadelphia, have installed this work, and new facilities have been provided for a reserve supply of 100,000 tons of anthracite and 50,000 tons of bituminous coal, which may be drawn upon in case of emergency, such as would result from a tie-up of the railways from any cause or combination of circumstances resulting in a coal famine. On account of the fact that the large new waterside station of the company in the city of New York consumes 1,000 tons of coal per day on the average, and that the total coal bunker supply at the station would not hold out for more than about ten days if all further supply were cut off, the importance of the storage plant will be evident. On account of a lack of available space in close proximity to the station of the company, the storage plant was located at Shadyside, New Jersey, a point on the Hudson River about opposite 110th Street in New York. Connections were made with the New York, Susquehanna and Western, and other railroads from the coal districts, and the necessary dockage facilities are available for reshipment by boat to the stations in New York. A frontage of 460 ft., and a depth of 1,500 ft. was secured on the river, and at the water front a dock 20 ft. in width was installed to carry the high speed hoisting tower and bridge tramway for handling to and from boats. The ground at the rear of the dock is filled with cinders that serve as a floor beneath the piles of coal in open storage.

Two anthracite piles of 50,000 tons each have available space in the yards, and adjacent to the dock a 50,000 ton bituminous pile. The rear of the site

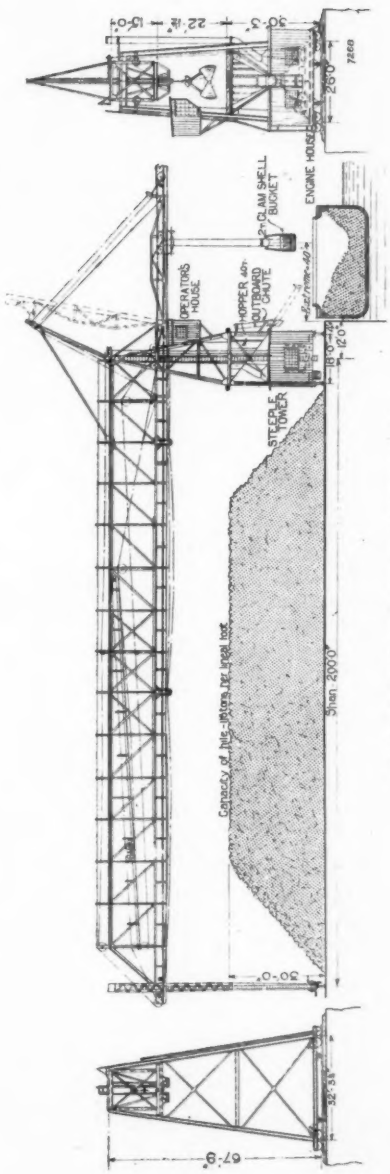


FIG. 1.—ELEVATION OF EDISON COAL STORAGE PLANT.

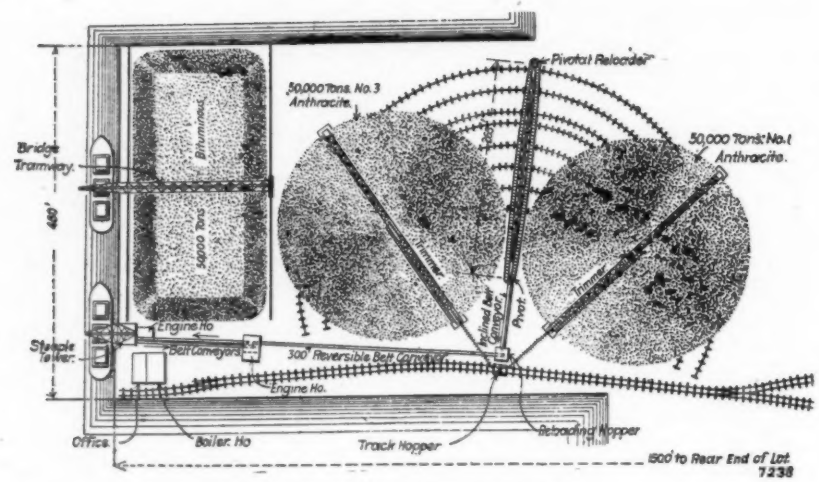


FIG. 2.—PLAN OF EDISON COAL STORAGE PLANT.

is occupied by storehouses for miscellaneous storage for the company, and in addition there is room for an additional anthracite pile if needed. The anthracite coal is handled by "Dodge" trimmers for piling, and a "Dodge" radial pivotal reloader for removal; delivery being made by belt conveyers to the dock, where a steeple tower is installed for the loading and unloading of boats. The bituminous coal is stored in a rectangular pile, the handling to and fro being accomplished by a traversing bridge tramway which spans the pile.

The accompanying illustrations show the construction of the traversing bridge for the bituminous coal pile. A bridge is provided for carrying the trolley for cross movements of the coal bucket, and has a span of 200 ft. between centres of support, the clear height under the trolley runway being sufficient to permit handling the bucket over a 30 ft. pile of coal. The bridge is supported at the dock end by a tower 67 ft. in height, which carries in the housing at its base, the boiler and engines for operating the hoists, trolley traverse and longitudinal movements. The structure is carried on three lines of rails, extending over 400 ft. along the line of the dock, so as to cover all parts of the pile; in moving the structure is operated by its own power.

A 2-ton clam shell bucket, which travels on a runway connecting with a boom projecting over the water, handles the coal in unloading from boats. The boom is of sufficient length to permit the bucket to be extended out 40 ft. beyond the dock line, and it may be lifted to a vertical position to permit of masted vessels passing when docking. For loading the vessels the bucket discharges into a 40-ton steel hopper above the engine housing, from which a swivelling outboard chute is hung for delivering and trimming. Two standard engines are used for the operation of the bucket, one for the closing and hoisting, and the other for the trolley traverse. The former has 12 by 12 in. cylinders, and the latter 10 by 12 in. cylinders. Steam is supplied to these engines by a 5 by 12 ft. vertical tubular boiler, also carried in the tower.

The anthracite handling plant is designed for receiving either by boat or rail, but the bituminous coal is arranged

for handling only by boat. It is dumped from cars directly into a track hopper, from which the "Dodge" trimmers distribute it to the circular piles when received by rail. The trimmers are of the standard "Dodge" type of inclined truss, with scraper conveyer leading up one side. Openings in the scraper trough permit the coal to be dumped at any point on the pile desired. When the coal is received by boat it is handled by a steeple tower at the dock, which, by means of a 1·5-ton clam shell bucket lifts the coal on to a belt conveyor system. This extends back and delivers into the track hopper near the anthracite piles which feed the trimmers as when received by rail.

A steeple tower is located on the docks permanently, and has a total height of 90 ft., while the overhanging boom permits of an extreme position of the bucket 30 ft. beyond the dock line. The trolley runway extends back over a 40-ton hopper in the upper part of the tower, below which are two weighing hoppers, and still below these a discharging hopper for delivering the coal received to the belt conveyor leading back to the trimmers. The 40-ton hopper into which the clam shell bucket dumps has sufficient capacity to keep the weighing process continuously in operation when unloading from a boat. The weighing is accomplished by keeping the two weighing hoppers, which are of five tons capacity each, alternately filling and dumping; when one becomes filled the feed is shifted to the other, &c., so that the process is simplified to a mere counting of the number of times each hopper is filled.

In this tower the bucket is operated by double-cylinder engines, consisting of a smaller engine superimposed above a larger one. The smaller, which has 10 by 12 in. cylinders, operates the trolley, while the larger, with 15 by 24 in.

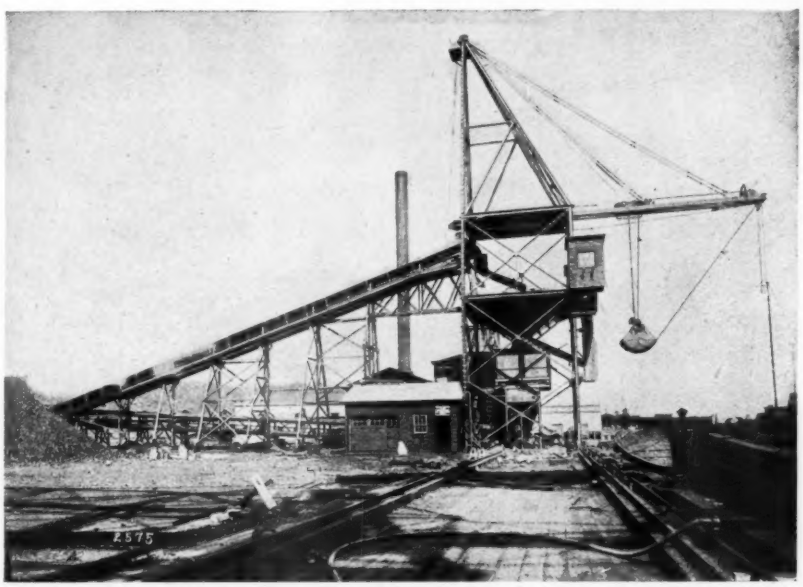


FIG. 3.—INCLINED BELT CONVEYOR, STEEPLE TOWER, AND CLAM SHELL BUCKET: EDISON COAL STORAGE PLANT.

cylinders, operates the bucket closing and hoist. These engines are both of the direct connected type, so that the hoisting and traversing movements are unusually rapid. The cable drums, which are 30 and 32 in. diameter respectively, are mounted directly upon the engine shafts, being connected at will by special friction clutches. These are controlled from the operating houses for all movements, the hoist by one man and the traverse by another, for facilitating the work. Very rapid unloading has been secured with this arrangement, as many as four trips per minute being possible under favourable conditions, and 2·5 trips per minute, or 150 per hour, being an average working rate, a capacity thus of 225 tons per hour.

The belt conveyors and the arrangement of the same is shown in the accompanying drawing of the yard plan. A 24 in. reversible belt conveyer extends from the track hopper between the trimmers to the engine house, where it discharges on to a 24 in. inclined belt conveyer delivering up into the 40-ton hopper in the tower for loading on to vessels, or receives by another inclined descending belt conveyer of the same size, coal that is taken from vessels and weighed in steeple tower, and discharges it on to the storage piles. The belts are operated at a speed of 600 ft. per minute, being driven by a 12 by 16 in. single engine located in the small engine house situated midway between steeple tower and storage piles. The combined capacity of the unloading and weighing apparatus in the steeple tower and the belt conveyor system and trimmers, is about 800 tons per day of ten hours, when operating under average conditions, although under the most favourable conditions nearly 1,200 tons have been handled in ten hours.

For the removal of coal from the piles the reloading system includes a reversible side scraper conveyer of the pivotal type swinging over a radius of 300 ft., which delivers at its pivot to a 30 in. inclined belt feeding 5-ton weighing hoppers that spout to the reversible conveyer. It is carried on ten lines of circular track, one of which is used for the cable mechanism for moving the reloader into the piles; the possible movement is sufficient to cover the entire area occupied by both piles.

FIG. 4.—BRIDGE TRAMWAY SPANNING BITUMINOUS COAL PILE: EDISON COAL STORAGE PLANT.

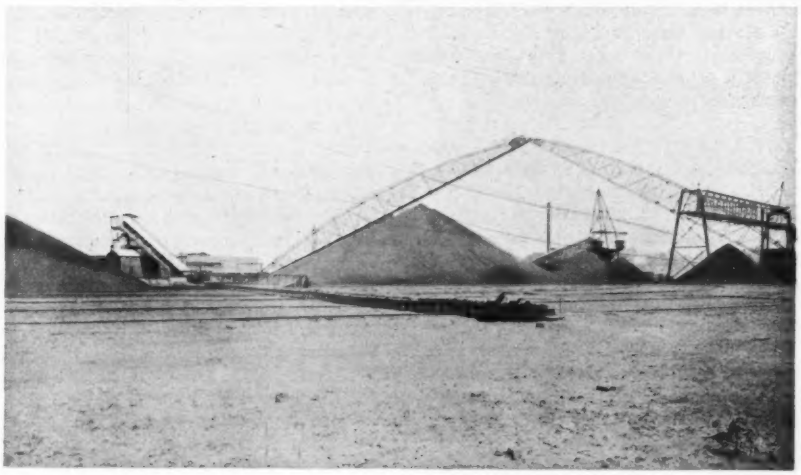


FIG. 5.—GENERAL VIEW OF ANTHRACITE PILES AND PIVOTAL RELOADER' EDISON COAL STORAGE PLANT.

This reloader as well as the trimmer mechanism is operated by a 16 by 18 in. single engine in house at rear of reloader tower between the piles. The capacity of the reloader is, under ordinary conditions, 1,500 tons per ten hours, although this rate has been considerably exceeded.

The three engine equipments are supplied with steam for operating the anthracite handling system by a boiler plant in a building near the dock, which also serves as an electric lighting plant, shop, and office. There are two 6 by 18 ft. horizontal tubular boilers rated at 150 h.-p. each. The lighting plant comprises a 100 kw. General Electric 240 volt generator, which is direct connected to a 150 h.-p. Ball and Wood simple engine. This is used for lighting the yard and apparatus, about 250 incandescent lamps being distributed for night operation.

The Commercial Value of Electrolytically-Produced Hypochlorite Solutions.

By W. POLLARD DIGBY, A.M.I.E.E.

BROADLY speaking, electrolytically-produced solutions of the hypochlorites of soda, magnesium and calcium, have two main uses, (a) as disinfecting agents or germicides, and (b) as bleaching agents. So far as the United Kingdom is concerned chief attention has been directed to the former object, and there were a number of installations erected in the early nineties for the purpose of sewage treatment, such as those at Worthing, Netley, Ipswich, and Maidenhead, the two rival systems being those of Hermite and Woolf. In the United States prominence was secured by Woolf's system. Latterly we have had a revival in this country of interest in the matter, and a new process has been tried at Guildford, while the Medical

Officer of a London Borough Council (Poplar) has recommended his committee to instal an electrolyser for the purpose of providing a cheap disinfecting liquid for municipal use.

Dealing first with the sanitary aspect of the case, it may be pointed out, that, to recommend them such solutions have certain marked advantages, these including :—extreme rapidity of action, ease of application, non-poisonous nature, plant does not require skilled supervision when once the installation has been turned up to the correct working pitch. Raw material required is plentiful and cheap. Electrical power for conversion by a motor generator to the required voltage can now be had cheaply in almost every town.

On the other hand, very little has been made public concerning the failures and difficulties which have confronted those endeavouring to extend the use of these germicides; the difficulties which are electro-chemical in their nature are: —(1) the cost of the electrolisers, in particular when the anodes are of platinum; (2) the difficulty which arises with certain types of apparatus of producing a stable solution; (3) the electrochemical efficiency which is often low: (4) the relatively low yield of available chlorine when considered in its relation to the amount of chlorine which remains unconverted from the chloride to the chlorite form; (5) wear and tear of anodes.

The difficulties which are not electrochemical are partly due to the attempts made repeatedly, but with the remotest prospects of success, not merely to sterilise, but to oxidise, the organic constituents of crude sewage, or exceedingly impure effluents. It is easily possible to disinfect either of these, and to render the latter sterile, but the complete oxidation of organic matter by hypochlorite solutions is commercially impossible, The other difficulty which limits the application of hypochlorite solutions as sterilising media pure and simple is the fact that while the Thames Conservancy and kindred Boards lay down very stringent standards as to the amounts of organic substances which constitute pollution in any effluent, they do not lay down any standard in regard to bacteriological condition. The argument of the analyst of such authorities is to the effect that, even if pathogenic organisms be present in chemically good effluents, *i.e.*, in effluents containing very little albumenoid ammonia, an absence of the organic substances on which bacteria feed will result in their ultimate extinction, either in the river itself or in the filters at the water-works. The bacteriologist argues that if the pathogenic bacteria be eliminated at one sweep, the organic substances entering a water-course, if the proportion be not too large, will in the natural course of events be oxidised in the river itself, while if disease-producing bacteria find their way into a drinking water, serious consequences result. The ideal lies in the blending of the two views. Chemically the analyst should be satisfied as to the purity of the effluent, a state of affairs which septic tanks or bacteria beds, or similar devices, are well competent to provide, in that they allow the bacteria (both pathogenic and non-pathogenic) to destroy the organic matter. Bacteriologically, the pathologist would be satisfied with a "wiping out" of the bacteria when they have performed the reasonable service demanded of them by the chemist. Their destruction at this stage would remove a potential source of danger.

For a complete and rapid means of wiping out the bacteria hypochlorite solutions are practically instantaneous in their action. Laboratory tests on solutions containing specific organisms, have proved that the spores of anthrax are killed in three minutes, and the bacilli of typhoid and diphtheria in one minute. Rough tests on all manner of putrid substances have shown that the evolution of foetid odours is almost immediately checked.

Very little need be said concerning the ease of application of these solutions, it suffices if the sterilising liquid is poured into the liquid requiring sterilisation, and the mixture allowed to take place in

glazed earthenware pipes laid with a fall of one in fifty with manholes in which baffle boards or weirs can be placed, at two intervals within 200 yards. Long before the outfall is reached, complete mixture will have been effected.

As to the non-poisonous character of these solutions, the strength at which they should be supplied for household use, say about 4 grammes per litre, is perfectly safe. The taste is somewhat nauseous, but no ill effects can follow. So far as sewage treatment is concerned, if there be faint traces of chlorine present in the effluent, say about two or three one-hundredths of a grain per gallon, no injury whatever takes place to the small fry of fish.

Turning to the problems accompanying the manufacture of such solutions, very little has been made public concerning the cost of these plants per kilowatt of normal capacity. Where platinum is used, the thickness of the foil employed varies considerably. The writer prefers to use foil of ·003 or ·004 of an inch in thickness, and in certain installations for which he has been responsible, the weight of platinum foil of ·003 of an inch in thickness required per kilowatt of normal load is practically 14 ounces troy. Platinum has of late advanced to the very high price of 84s. per ounce, an increase of 25 per cent. in ten years. The chief continental inventors, Haas, Stahl, Oettel, and Kelner have apparently discarded platinum for special forms of carbon, such as retort carbon, or Acheson's graphite. While graphite is as unoxidisable as platinum for use as an anode in hypochlorite solution, it is, however, subject to a disintegrating action, and therefore requires renewal from time to time. The writer has not had a sufficiently extensive practical experience of graphite anodes to estimate the cost of renewals, but it may be pointed out that the initial cost falls from pounds to shillings.

As regards stability, in the early days of hypochlorite making, the extreme instability of the liquids produced was a severe drawback, but attention to the details of manufacture, reduction of current density, and a careful regard for temperature have done much to remedy this, so much in fact that relatively stable solutions—which kept in dark-coloured stoppered bottles will only lose about 2½ per cent. per annum of their strength in available chlorine—have for several years been made and sold in bottle form in this country. For large scale working, however, such as for sewage treatment or bleaching purposes, a depreciation of two or three per cent. per diem is no bar to economic production so long as the storage capacity is not

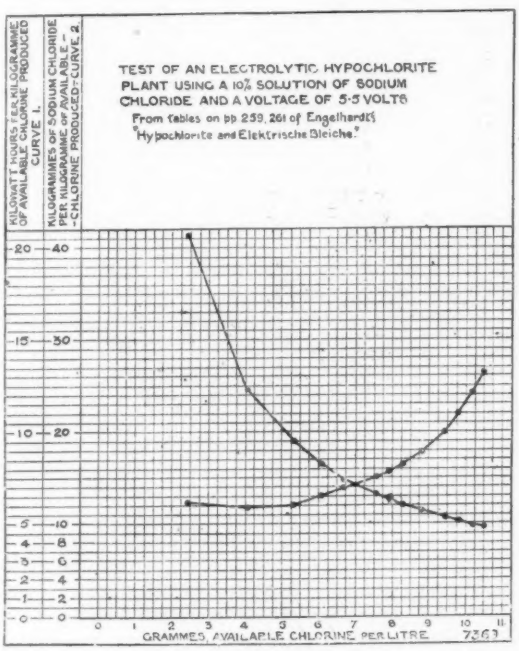

TEST OF AN ELECTROLYTIC HYPOCHLORITE PLANT USING A 10% SOLUTION OF SODIUM CHLORIDE AND A VOLTAGE OF 5·5 VOLTS
From tables on pp 259, 261 of Engelhardt's "Hypochlorite and Elektrische Bleiche."
KILOWATT HOURS PER KILOGRAMME OF AVAILABLE CHLORINE PRODUCED CURVE 1.
KILOGRAMMES OF SODIUM CHLORIDE PER KILOGRAMME OF AVAILABLE CHLORINE PRODUCED-CURVE 2.
20 40
15 30
10 20
5 10
4 8
3 6
2 4
1 2
0 0
0 1 2 3 4 5 6 7 8 9 10 11
GRAMMES AVAILABLE CHLORINE PER LITRE
7363

FIG. 1.

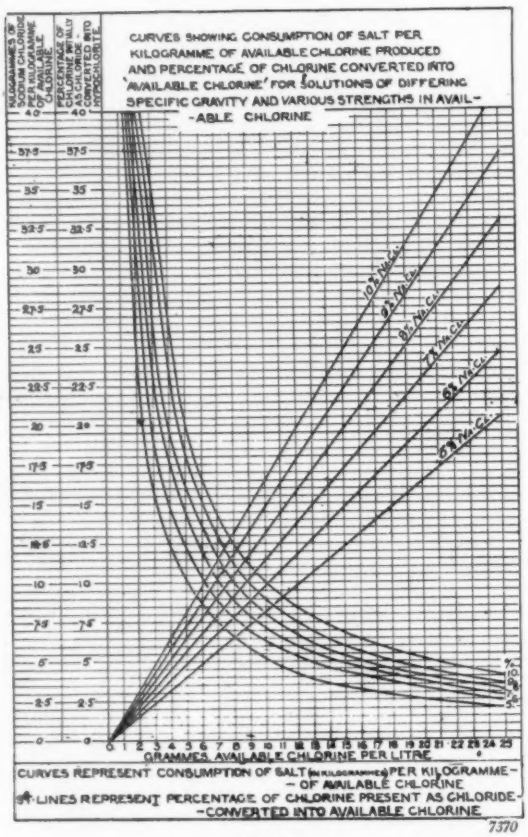

CURVES SHOWING CONSUMPTION OF SALT PER KILOGRAMME OF AVAILABLE CHLORINE PRODUCED AND PERCENTAGE OF CHLORINE CONVERTED INTO 'AVAILABLE CHLORINE' FOR SOLUTIONS OF DIFFERING SPECIFIC GRAVITY AND VARIOUS STRENGTHS IN AVAILABLE CHLORINE
GRAMMES AVAILABLE CHLORINE PER LITRE
CURVES REPRESENT CONSUMPTION OF SALT IN KILOGRAMMES PER KILOGRAMME OF AVAILABLE CHLORINE
LINES REPRESENT PERCENTAGE OF CHLORINE PRESENT AS CHLORIDE CONVERTED INTO AVAILABLE CHLORINE
7370

FIG. 2.

disproportionate to the rated output of the plant. The writer regards it as impossible to formulate for different electrolisers any rule as to the relation of stability of product for different strengths of solution. It is difficult but not impossible to do this for one type of apparatus regarded by itself, owing to the difficulty of exactly reproducing any particular cycle of temperature changes parallel with an exactly similar efficiency curve.

The effect of instability of solution during manufacture is to cause an abrupt falling off of the efficiency, whether measured in percentages of the theoretical yield per ampere hour or per kilowatt hour. The custom of the leading German authorities in considering the yield in percentages of the theoretical quantity produced per ampere hour does not commend itself to the present writer. If we are to think in percentages at all, we ought surely to think in percentages of the theoretical yield per kilowatt hour, which method takes account of the differences in potential used in different types of apparatus. The following curves are a reproduction of one of the tests recorded in Herr Viktor Englehardt's "Hypochlorite und Electrische Bleiche," and are quoted as instances of fairly typical results, showing as they do the relation between strength of available chlorine per litre, and the energy consumption per kilogramme of available chlorine, and the salt consumption per kilogramme of available chlorine at these strengths. As to the costs of electrical energy, and of salt varying in various districts, no attempt to show these has been made. The reader can in any case prepare these for himself; in so doing he will find that the point of cheapest working will vary with respective prices, and that the decreased quantity of salt used is counterbalanced by the rise in the energy required. Mention may be made in passing of the fact that the characteristic curves for any electroliser of the kilowatt hours per kilogramme of available chlorine produced vary with the specific gravity employed, and also with the volume of the contents in the electrolising tanks, by reason of the depreciation which takes place as higher strengths are reached, and which, as has already been stated, causes an abrupt fall in the efficiency of production.

An important feature in regard to the treatment of sewage effluents is that at the economical working strength a large quantity of the chlorine present as sodium chloride remains unconverted into available chlorine and is therefore wasted. The extent of this is illustrated in Figure 2 for solutions of sodium chloride varying in specific gravity from 1·050 to 1·100. Taking the final strength attained in the test illustrated in the figure of 10·4 grammes of available chlorine per litre, it will be found that only 17 per cent. of the chlorine initially present is capable of doing effective work in the form of available chlorine. Taking the intermediate strength of six grammes per litre, which would probably correspond to the cheapest working point in most English industrial centres, only 10 per cent. of the chlorine present in the chloride form is converted into hypochlorite. That is to say, there would be added to the effluent an amount of useless sodium chloride large in proportion to the amount of sodium chloride representing useful work done in the reversion of the oxygen carrying hypochlorite molecule to its inert chloride form.

Pocket Books and Diaries.

The "Practical Engineer" Pocket Book, 1906, and the "Practical Engineer" Electrical Pocket Book, 1906. Manchester. The Technical Publishing Co., Ltd. Price 1s. net each.

It is increasingly difficult to keep pocket books up-to-date and still maintain a size within pocket dimensions. In the case of these useful and practical annuals, not only has this been effected, but much useful matter has been added, combined with a thorough revision.

Clarke, Chapman & Co., Ltd., Gateshead-on-Tyne. Useful pocket diary for 1906.

Edward Wood & Co., Ltd., 88, Cannon Street, E.C. Pocket diary for 1906, containing many useful tables, in particular a new series dealing with safe loads for compound girders and stanchions.

Robt. Boyle & Son, London and Glasgow. Pocket calendar and case for 1906.

The Charing Cross Railway Station Disaster.

In the following article we give a brief description of the Charing Cross station roof and some particulars relative to the condition of the ironwork and of the tie-bar, to the failure of which the recent accident has been very generally attributed, although the correctness of this view remains to be ascertained by investigation.

The station was built in 1860 from the designs of the late Sir John Hawkshaw, and the contractors for the roof were Messrs Cochrane, Grove & Co., of Dudley. The area covered measures about 500 ft. long by 165 ft. wide, the roof being supported by the eastern and western walls, which, owing to the contiguity of the streets on either side, were built without buttresses, being intended to support purely vertical loads. Consequently, the roof principals were designed as arched trusses so that the outward thrust should be taken up by the tension members. The height of each wall above platform level is 40 ft. and the total height increases from the same measurement at the Strand end of the station to something like 60 ft. at the Embankment.

The walls consisted of brick piers 3 ft. to 4 ft. thick, connected by arches and filled in with 18 in. brickwork, stone blocks being mounted on the pier tops to receive the feet of the roof trusses, and the ends of the 100-ton box girder at the bottom of the wind screen. The southern ends of the walls were terminated by piers rather thicker than those mentioned above, but still not giving anything like the strength which is afforded by the two massive towers at the corresponding end of Cannon Street station. Of course, below rail level the outer walls are strengthened by the massive masonry arches beneath the station.

After the completion of the station it was decided that the Villiers Street wall should be stiffened by the addition of buttresses projecting about 17 ft. beyond the wall piers for the purpose of resisting horizontal wind pressure. These buttresses were arched and through them proceeds the gangway giving access to the Charing Cross footbridge.

Fig. 1 is an elevation of one roof truss, and shows the east and west wall piers in section. The entire roof includes fourteen principals of this design, spaced 35 ft. apart, in addition to the wind screen, which is of different

construction. The main girder of each principal is a curved wrought-iron plate girder with a versed sine of 45 ft., and was built up of a web plate 18 in. deep by $\frac{1}{2}$ in. thick, and flanges formed of 6 in. by 3 in. by $\frac{1}{2}$ in. angle bars. At each end, the rib is split and opens out to the width of 2 ft., as represented in Fig. 5. At the eastern end, the principal is fixed to the stone cap shown on the top of the wall in Fig. 1., and at the west end there is a saddle, designed on the suspension link principle, the construction of which is shown in Fig. 2.

The bracing of the main rib consists of eight vertical struts each consisting of two 6 in. by 3 in. by $\frac{1}{2}$ in. T-bars; two diagonal ties of 4 in. by $\frac{1}{2}$ in. bars in each panel; and a tie-bar in nine connected sections. The struts and diagonals are riveted to wrought-iron plates connected with the main rib (see Fig. 3), and to similar plates connected with the couplings of the tie-bar (see Fig. 4). The centre panel is now subdivided by an additional vertical. The different lengths of the tie bar have the following diameters: end panels $4\frac{3}{4}$ in., second panels $4\frac{5}{8}$ in., third panels $4\frac{1}{2}$ in., fourth panels $4\frac{3}{8}$ in., centre panel $4\frac{1}{4}$ in. Each end section of the tie-bar is fixed into the connection projecting from the foot of the truss, as shown in Fig. 6, cotter and gib fastenings being provided for purposes of adjustment. The enlarged ends of each tie-bar section are screwed into the coupling boxes, and, in accordance with the practice usual at the time when the bridge was built, are welded to the body of the bar. Each adjoining pair of roof principals is connected by sixteen purlins consisting of girders 19 in. deep, with latticed webs formed of 2 in. by $\frac{5}{8}$ in. bars, and flanges consisting of two $3\frac{1}{2}$ in. by 3 in. by $\frac{1}{2}$ in. angle-bars. The purlins are stiffened by two parallel lines of bracing, and the glazing of the roof is supported by wrought-iron sash bars of T-section.

Let us now consider briefly the order in which the various stages of the disaster developed after the first warning afforded by the sudden snapping of the tie-bar in the truss next to the wind screen at the southern end of the station. This appears to have taken place at 3.30 p.m. on December 5th, and was almost immediately followed by the gradual descent of the broken end of the bar until that member assumed an angle of about 20 degrees from the horizontal. The part of the bar that gave way was $4\frac{1}{2}$-in. diameter section at the third bay from the west wall of the station, but as the connections at the foot of each strut between the point of fracture and the wall broke away, the first and second sections, and part of the third section hung loose. Therefore one third of the span would naturally tend to spread out towards the west, this action being resisted for a time by the stiffness of the main rib, the strength of the bracing, and the reaction of the outer wall. Very little reliance could be placed upon the latter for, as we have previously shown, the walls were not designed to resist lateral pressure. The main rib also would not be able to assist to a very material extent in retaining its curved form, and the greater part of the work would naturally fall upon the struts and diagonal ties.

At 3.45 p.m. the glazing of the roof began to fall, and, according to the account of an eye-witness, the semi-circular wind screen at the end of the station moved towards the west and fell. These effects were probably caused by the gradual spread of the roof principal, exerting pressure against the wall so as to push it outwards sufficiently to drag the wind screen girder from its seat on the east wall. It appears, however, that the damaged truss kept its position for a few minutes more before the final collapse that brought down two complete bays of the roof and overturned the upper portion of the wall, the fragments of which fell upon the Avenue Theatre. The evidence of two or three witnesses examined before the coroner makes it doubtful whether the wind screen fell before or after the roof truss. The witnesses in question believe the last-mentioned member fell first, but the precise sequence does not alter the main fact that the collapse was brought about by the gradually increasing spread of the truss.

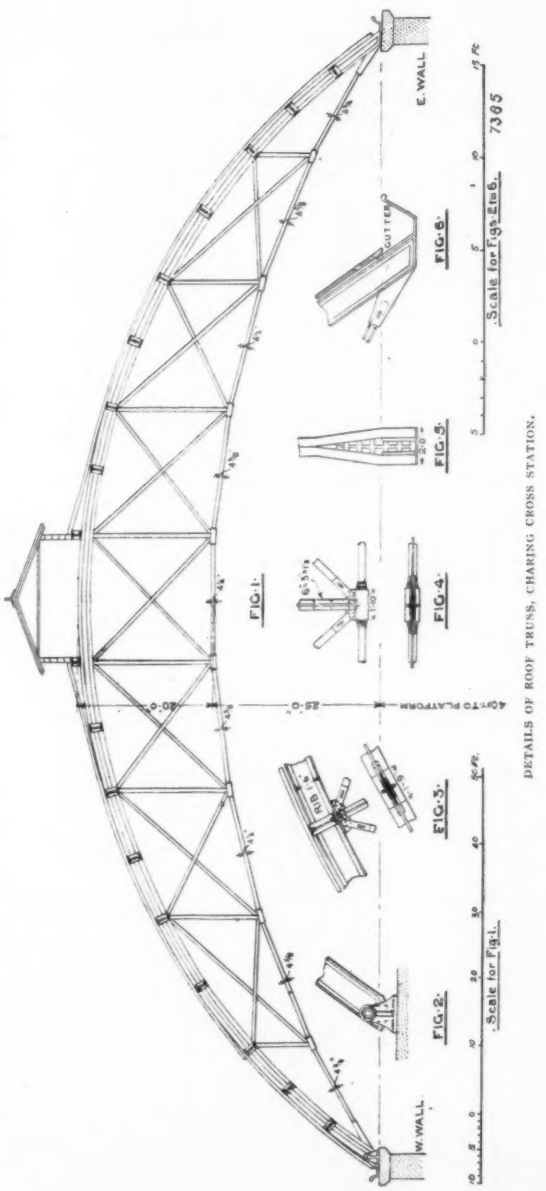
The damage done to the Avenue Theatre is of very serious character. One of the coping blocks from the station wall, having the weight of about 63 cwt., penetrated the roof, and the stage floor, and finally came to rest in the basement. Other portions of the roof were wrecked by parts of the wall falling from above, the ceiling was smashed in, and the whole interior became an astonishing scene of ruin. Moreover, the outer wall of the theatre, facing the Embankment, was so seriously injured that at the time of our visit to the premises, the upper portion projected at least 8-in. below the base.

In a statement issued by Mr. Vincent Hill on behalf of the South Eastern and Chatham Railway, it is said that the disaster was apparently due to the breaking of a tie-rod or to a settlement from some unknown cause which had placed undue strain upon the tie-rod. We carefully abstain from any attempt to prejudge the findings

of the official inquiries as to the origin of the collapse. But we may state, after examination of the fallen ironwork, that whatever may have been the circumstances leading to the fracture of the tie-bar, that member was in an undoubtedly critical condition immediately before the disaster took place.

The fracture of the tie-bar, viewed longitudinally, exhibits a more or less uniform slope of nearly 45 degrees, and is distinctly suggestive of a scarf weld. Viewed transversely, the end of the bar shows a rusty portion of irregular triangular form, with an area of about two-thirds that of the entire cross section. In the middle of the triangle there is a core of darker colour presenting pits, or cavities, and in only three places has the metal the crystalline lustre suggestive of recent fracture. The collective area of these three parts is little more than one-third the total area of the cross section. So far as we could judge, the quality of the metal in the bar appeared to have been excellent in itself, and should it ultimately be proved that the failure took place in consequence of a defective weld, and not owing to some unexplainable cause, much of the uneasiness now existing among those who make use of iron and steel in constructional work will undoubtedly be removed.

One significant fact deserving special notice is that the tie-bar of the second principal has also broken and separated from the connections at the second and third panels on the eastern side of the station. As the roof bay supported by the truss in question has not collapsed, it is reasonable to infer that the wall stiffened by buttresses has been able to act as an efficient abutment. Assuming this to be a correct view, the circumstance is not without its bearing upon the failure of the western wall, and the evidence that will doubtless be forthcoming with regard to the point raised should be carefully watched.



DETAILS OF ROOF TRUSS, CHARING CROSS STATION.

The general condition of the fallen girders and other ironwork is of considerable interest. The metal has suffered most seriously by exposure to atmospheric influences. In illustration of the extent to which corrosion has proceeded, we may mention the fact that in one section of the main rib the web originally of $\frac{1}{2}$-in. plate had rusted away until the thickness was little more than $\frac{3}{16}$-in. Indeed, in one portion of this member a 3-in. T-bar had been driven clean through the web, showing the important reduction of strength that has taken place since the girder was first built. These facts show very clearly the necessity for the periodical cleansing and painting of ironwork in exposed positions, and they also suggest the desirability of skilled inspection and the replacement of defective members. As we have already said, the first cause of the disaster remains to be discovered, but the present state of the ironwork points to the unpreparedness of at least one important member for the resistance of unaccustomed strain. That the other members in their attenuated condition should have been able to hang together for so long after the rupture of the tie-bar is a satisfactory testimony to the soundness of the design, materials, and workmanship of the structure.

The "Watt" Suction Gas Producer.

In considering the subject of suction gas-producer design, it must be borne in mind that, simple as the apparatus appears to be, it must, nevertheless, in its working, exhibit a sensitiveness to changes in the demand of the engine, in order that the heat generated may be used in the most efficient manner. Unless the apparatus, in its operation, be delicately balanced, and valves and connections be simple in character and easy to manipulate, the tendency to make bad gas, and therefore to be wasteful, is considerably increased.

A new type of apparatus involving features in design and construction which would appear to be novel, and further to indicate that attention has been devoted to the features mentioned, is that just introduced by Messrs. James Watt & Co., Soho Foundry, Birmingham, the details of which are given in the accompanying illustration.

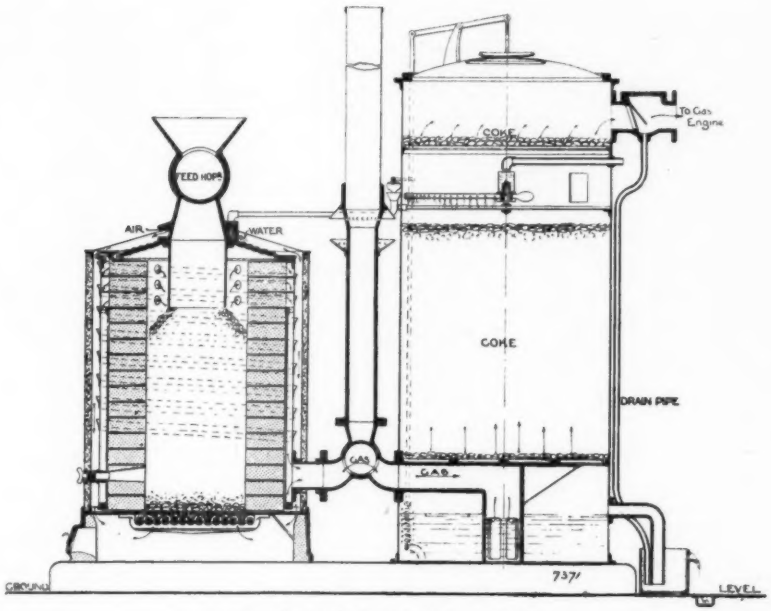
It will be observed that the fire bars are easily withdrawable, and can be individually rotated without admitting air under the grate. The case of the generator is double, and the hot gas, as generated, passes down an inner annular space. The air and steam descend an outer annular cavity, which, externally, is coated with heat-retaining material and lagged with sheet steel and brass bands. The steel case which serves as a wall between the inner and outer annular spaces is provided with a spiral trough on its outer surface, serving to conduct and distribute the water, which is fed on to the top of the generator, uniformly over the surface of the intermediate case, which is itself heated up by the outgoing gases.

The inner cover of the generator is made in the form of a volute trough which receives the water supply near its centre, the water flowing in a circular path and finding its way into the trough on the vertical side of the intermediate case referred to. The air drawn in through the cover and the vapour generated mix together, are heated up, and then pass under the grate.

It will be seen that no external vaporiser is employed, and also that the use of a boiler with many fittings, pipes, and connections is dispensed with. The gas is of course made by passing the mixture of steam and air up through the incandescent material, whereby decomposition results and gas is the product. With too much steam a rich gas is momentarily made, but the fuel cools down quickly and ceases to act. With too little steam the fuel clinkers from excessive heat, and poor gas is made, the energy being liberated in the generator instead of in the cylinder of the gas engine.

It will be noted that the connections are simple in character, there being but one two-way gas valve which directs the products from the generator either into the washer or up the waste pipe. It is impossible to operate this valve wrongly and so cause an accident. With a multiplicity of valves, there is the danger of their being operated in improper sequence, and so admitting air to the washer, thus forming an explosive mixture.

The method adopted of heating up the plant forms one of the distinctive features of the apparatus. The fire is laid in the generator and ignited and a little greasy waste or other inflammable material is then placed on the small circular grate on the waste pipe above the two-way valve already mentioned. On applying a light to this material an intense draught is caused up the waste pipe and very quickly combustible



THE "WATT" SUCTION GAS PRODUCER.

gases arise from the fire in the generator and themselves ignite inside the waste pipe at the point where the perforations are placed. The draught is thus maintained and the generator is quickly brought to making condition.

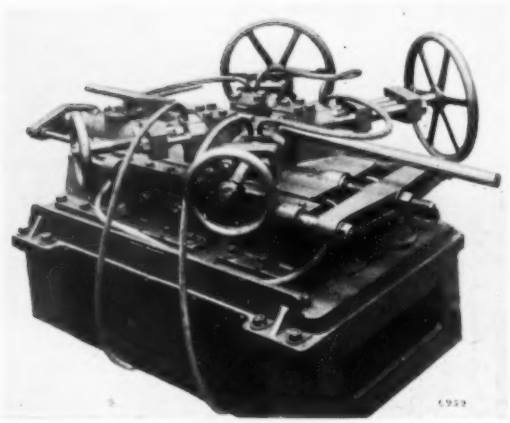
When the gas is passed into the washer for the first time the air is displaced by moving the flexible diaphragm up and down. This acts as a pump, the dip pipe acting as an inlet valve, and the flap valve at the outlet from the washer serves as delivery valve.

The gas is thoroughly washed in passing up through the column of coke, which is sprinkled by an automatic device rotated by the reaction of the water jets issuing from a perforated arm. In this way the whole surface of the coke is uniformly wetted. The gas on rising from the wetted coke passes through a layer of dry coke, which intercepts any spray or splashes of water. The flexible diaphragm serves a triple purpose—it acts as a pump initially as explained; it gives a steady supply of gas to the engine and causes air and vapour to pass uniformly through the hot fuel in the generator; it finally controls the water supply, each deflation of the diaphragm by a suction stroke of the engine producing a movement which is transmitted to the water valve, a specific quantity of water being thus liberated each time the engine takes a charge of gas.

Electric Welding Machine at Wolverton.

THE accompanying illustration is that of an electric welding machine installed at the London and North Western carriage works at Wolverton by the Electric Welding Co., Limited, 28, Basinghall Street, E.C., where it is employed for welding drop-forgings on to straight rods for making draw-bars, adjusting joint rods and double-head rod-ends for brake gear, truss rods for carriage underframes, joints and T pins for carriage springs, &c.

The method employed is as follows: Alternating current at 300 volts is converted by a transformer fitted in the base of the machine, into low pressure current used for welding. Upon the terminals of the secondary circuit of the transformer are



ELECTRIC WELDING MACHINE.

mounted heavy platens of gun metal, carrying the clamps into which the articles to be welded are placed. They consist of four sliding blocks arranged radially, which are operated by means of hand-wheels. In the illustration the blocks are shown as arranged for welding straight bars, axles, and such like; for circular work, such as tyres and rings, it is necessary to use contact-blocks of a slightly modified shape. The copper contact-blocks and platens are drilled and fitted for water circulation to keep them cool during the operation of welding.

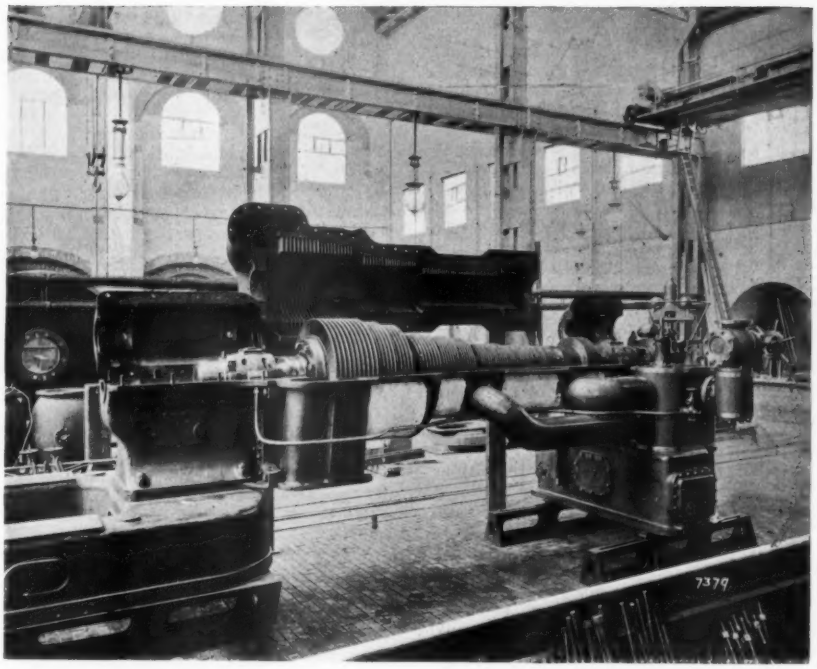
The necessary mechanical pressure for forcing the heated metal together and completing the weld is provided by a small reversible hydraulic jack, operated by a hand-lever, shown on the left-hand side of the welder, by means of which one of the platens carrying the clamping device is advanced nearer to the other.

To make a weld the articles are placed in the clamps, and firmly butted together. By means of a rheostat controller placed alongside the welder, which inserts resistance in series with the exciting circuit of the alternator field-coils, the operator is enabled to complete the exciter circuit and regulate the voltage of the alternator from zero to the maximum. The heating effect is thus under complete control, and the metal is rapidly heated owing to the resistance offered to the current at the point where the surfaces of the metal abut. As soon as the welding heat is reached, the current is switched off, and mechanical pressure applied by the hydraulic jack. The welded article is then transferred to a steam hammer (or anvil), where the swelling caused by the last operation is hammered down. The controller consists of a set of resistance coils mounted in a cylindrical-shaped case, and fitted with a small insulated handle on the top. All the technical knowledge required by the operator is that the turning of the handle to the right or left increases or decreases the heat, as the case may be.

Steam Turbines for the Bristol Corporation.

THE generating plant of the Bristol Corporation Electricity Works has recently been extended by the addition of a 1,000 k.w. turbine, constructed by Messrs. Willans and Robinson, Ltd., Rugby, a view of which is given in the accompanying illustration. Another and similar machine at present on the test bed of the makers, is shortly to be installed. Both turbines are designed for 50 per cent. overload working with 200 lbs. steam pressure and 200° superheat, and are of the re-action type, differing from the machines made by Messrs. C. A. Parsons only in detail of design.

The most important of the differences consists perhaps in the method adopted of fixing the blades, which, instead of being caulked in singly are fixed in the casing or the rotor in sections by a special patented process, and are connected at their outer ends by a channel strip rim. This provides a very rigid form of blading and forms a considerably increased baffle to the leakage at the ends of the blades. Great care has been exercised in the design to render every part of the turbine accessible. All the gear, such as throttle, valve, governors, oil pump arrangements, &c., are placed at the side or end of the machine so as to render it possible to open the casing or the bearings without disturbing anything else. It will be noticed that the casing opens on a hinge rendering inspection very easy and re-fitting exact. We are informed that one of these turbines has been opened in the maker's shops within 8 minutes from the time of first starting to undoing the bolts.



"WILLANS-PARSONS" TURBINE FOR THE BRISTOL CORPORATION.

Manchester's New Industry.

THE Manchester Corporation is about to undertake the construction of the tramcars running on its system, and for this purpose new works have been established in Hyde Road. The formal opening ceremony took place quite recently, and consequently the following description of them cannot fail to be of interest to our readers. These works, which comprise workshops and car shed, are the most modern and best equipped in the country. The entire site contains about 11 acres. The entrance to the car shed is in Hyde Road. This shed stands on about 4¾ acres of land, and houses nearly 300 cars. The area of land occupied by the car building and repairing shops is about 4 acres, and of this about 2½ acres are at present under cover. The works are divided into two parts. On the one side there are the wood-working and car body shops, and on the other side the mechanical and electrical shops. The main avenue is 50 ft. wide, and is provided with a 15 ton overhead electric travelling crane made by Higginbottom and Mannock, of Manchester, which is utilised for lifting car bodies and trucks. The wood-working side contains the machine shop, the cabinet makers' shop, the general car body repairing and building shop, and the paint shop. On the mechanical and electrical side are the smithy, the brass foundry, the machine shop, the truck shop, and the electric shop. The boiler house, stores, and mess rooms, &c., for the men are also on this side of the works. The buildings have brick sides and ends, and upright lattice girders assist to carry the roof. The contract for the iron and steel work was let to Messrs. Edward Wood & Co., of Manchester; the general builder's work being carried out by Messrs. Young, Tinker, and Young, of Manchester. The various workshops are heated by two

self-contained marine boilers, which supply hot water at low pressure through about five miles of circulating piping. With a view to protection against fire, the works are provided with an installation of 1,200 Grinnell automatic sprinklers, which are supplied with water from the street mains, and from a reserve tank of 7,500 gallons capacity. All the machine tools are electrically driven, power being obtained from the local sub-power station. The motors and shafting for the wood-working shops are in the basement. The wood-working tools comprise large and small band saws, circular saws, a 12 in. by 6 in. four-sided planer, a 24 in. planer, and a thicknessing machine, &c. The shavings and sawdust from this shop are conveyed by means of a cyclone sawdust collecting plant, from the shop through tubes to the boiler house. In the body repairing and building shop there are six pits running the whole length of the shop, and the lines of rails are continued out through the doors into the avenue, and thence on to the tramway system. The smithy is equipped with a pneumatic hammer driven by an electric motor, and eight fires. These are well arranged, there being a jet in each up-take to carry off the smoke. The brass foundry is provided with two 80 lb. and two 50 lb. pot holes. In the machine shop there is a fine range of tools, amongst which are two 12 in. lathes, a steel wheel turner, an emery wheel grinder, a radial arm drill, wheel borer, planer, slotter, brass finishing lathes, &c. These tools have been supplied by Kendall and Gent, Hulse & Co., and Craven Brothers. The truck shop is served by a 15 ton electric overhead travelling crane, by Higginbottom and Mannock; there is one pit in this shop. The general scheme of departments contributes to the greatest economy in operation, and the quickest passage of the various parts from the raw material to the finished article. Everything which modern enterprise has done towards the perfecting of workshop methods has been taken full advantage of. The total cost of the works and equipment has been £54,200. The architect was Mr. John Gibbons, of Manchester. The number of men employed at the present time at the car works is 220. In conclusion, we may say, that the management of the works is in the capable hands of Mr. John Eades, jun., A.M.I.Mech.E.

The Manchester Tramways Committee have found that the experiment of covering the tramcars has proved successful from the carrying point of view. The covered are more popular than the uncovered cars, and their earnings are more than sufficient to cover the additional cost. The committee have accordingly decided upon their general adoption. The number of covered cars is at present fifty-one, and in another couple of months the total will be seventy-five—all bogies. The committee have also discussed the advisability of covering the smaller cars, and have adopted a design which is to be tried on one car as an experiment. If it proves successful it will be generally adopted for the routes on which covered cars can be run. It is thought that only by covered cars can overcrowding be prevented.

Noise from Machinery and its Injunction.

A CASE of the utmost importance to machinery users all over the country was recently before the Court of Appeal. The point in dispute was the extent to which relief can be claimed on the ground of nuisance from noise. An injunction was granted in January last against Polsue, Ltd., a firm of printers in Gough Square, Fleet Street, London, at the instance of a milkman, who resided and carried on business next door, on the plea that the defendants, as newcomers, had caused at night, by the working of their printing machine, a substantial addition to the pre-existing noises of the district. The defence was that the noise was not substantial, and that, if it had been substantial, it arose from trading in the particular and established manner of the trade of the district, which was found in this instance to be devoted to printing. The plaintiff's counsel argued that prior residence gave the plaintiff prescriptive right to legally object to the noise; but this belief, which is almost universal in the lay mind and seemed to be present to the judge in the court of first instance, was declared by the appeal judges to be unsound and fictional. Lord Justice Vaughan Williams went further, and said that it would be inconsistent with the authorities cited to hold that it was a private and actionable wrong even if the night work caused a serious disturbance to the plaintiff in a locality devoted to a particular trade, provided the noise arose from working machinery in the established and customary manner of the district, nor did he think, though the noise was a substantial addition to pre-existing noises, that it would be a legal nuisance, provided, again, it arose from the regular and usual trade manner of working. He also added that he should not have found from the evidence before him that the noise made by the defendants was a great noise. But, although finding thus in the defendant's favour on points of law and

fact, he nevertheless allowed the judgment of the court below to stand because he did not wish to dissent from his learned brethren, Lords Justices Stirling and Cozens-Hardy, who thought that interference with the decision would involve, contrary to the practice of the Court of Appeal, the over-ruling of Mr. Justice Warrington, who gave the injunction on matters of fact. The points at issue are of crucial moment to machinery users, and the appellants in our opinion are amply justified, and should be supported in the notice they gave of carrying their case to the House of Lords, where court practices as to findings of fact are handled with greater freedom and fairness. An authoritative decision by the House of Lords on the lines of the judgment of Lord Justice Vaughan-Williams would give machinery users a sense of security which at present they cannot feel.

Catalogues and Trade Publications.

John Davis & Son, Ltd., Derby.—Leaflet A 060 Davis' speedometer for showing at a glance "revolutions per minute" of stationary engines or any revolving machinery, and Leaflet 059 on the Smith-Davis Piece-work Balance and Premium Calculator.

Mechan & Sons, Ltd., Glasgow.—Steam dryers for extracting water and grit from high pressure steam, and oil separators for the removal of oil and grease from exhaust steam under Prof. Watkinson's patents.

C. Whittaker & Co., Ltd. (1900), Union Foundry, Haslingden.—Catalogue of steam engines, power transmission gear, and castings.

General Electric Co., Ltd., 71, Queen Victoria Street, E.C.—New complete bound catalogue, 1905–6 edition, consisting of over 1,600 pages, and divided into thirteen different sections, comprising "Witton" motors and dynamos, switchboards, electric light supplies, measuring instruments, engineering supplies, electrical heating and cooking apparatus, fittings and glassware for electric lighting, wires and cables, steel conduits, bells, telephones, and motor car accessories.

H. M. Budgett, Crown Works, Anchor Street, Chelmsford.—Circular dealing with surface plates having a high-class surface produced by a special finishing process, and guaranteed accurate to $\frac{1}{5000}$ and $\frac{1}{1000}$ of an inch.

Neville Bros., 7–9, James Street, Liverpool.—Catalogues of labour-saving machines and tools for electrical engineers, &c.

Chas. Winn & Co., Birmingham.—Illustrated catalogue, D38, of boiler and engine fittings. A speciality to be noted in this list is an improved parallel slide stop valve, in which a pair of wedges and springs are employed in combination with other parts.

Mavor and Coulson, Ltd., 47, King Street, Glasgow.—Monthly calendar card for December, 1905, illustrating electric direct-current Pick Quick coal cutter.

Gilbert Arc Lamp Co., Ltd., Chingford, Essex.—1905–6 descriptive list of this firm's specialities in arc lamps, both open and enclosed, and all necessary accessories.

Mather and Platt, Ltd., Manchester.—Copy of two-cycle gas engine catalogue, fourth edition, containing descriptions and diagrams of some successful installations.

Mitchells, Ashworth, Stansfield & Co., Ltd., 12, Newgate Street, E.C.—Catalogue of impregnated felt for reducing vibration and sound.

B. J. Hall & Co., 39, Victoria Street, S.W.—Copy of the bargain book for drawing office requisites, published monthly by this firm.

Industrial Notes.

The Stirling Boiler Co., Ltd., Motherwell, inform us that Mr. John Cowan has resigned his post of managing director, though still retaining that of chairman of the directors. Mr. E. G. Constantine has been appointed in his place.

Pulsometer Engineering Co., Ltd., Reading, have received an order from the Worksop Urban District Council for a "Criton" water softener, of 1,500 gallons per hour capacity, for their electricity station.

Mason's Gas Power Co., Ltd., Levenshulme, Manchester.—With the idea of increasing the efficiency of their staff, this firm have arranged for a course of lectures on technical subjects, the first to be given being "The Slide Rule: Notes on the Value of the Answer." The effort is much appreciated by the staff.

Messrs. Mather and Platt, Salford, Manchester, have appointed Mr. Bertram S. Giles, M.I.E.E., as their chief representative for London and the South of England for their electrical and hydraulic departments.

Ed. Bennis & Co., Ltd., Little Hulton, Bolton, have lately received repeat orders for their mechanical stokers from the Babbington Coal Company, Ltd., Nottingham, and the Wimbledon Urban District Council; and other orders have been received from the Swadlincote (Derby) Urban District Council, the Rugby Urban District Council, Messrs. Clarke, Chapman & Co., Ltd., and the Patent Shaft and Axletree Co., Ltd., Wednesbury.

Locomotive and Railway Notes.

By CHAS. S. LAKE.

The Compound Locomotive in Great Britain.—Signs are not wanting that British locomotive engineers, taken generally, are more inclined at the present time than ever before, to view with favour the introduction of compound locomotives on the main lines of this country.

True, the majority of railways still employ simple locomotives in great preponderance if not entirely, and instances are at hand of a return to the construction of such engines after giving those operated upon the compound principle a thoroughly exhaustive trial. Still, in spite of all this, there is an unmistakable tendency towards more closely investigating the claims of those who advocate the use of multiple-expansion cylinders; and good work is being done, with greater economy than heretofore, by compound locomotives on lines to which, until comparatively recently, they were absolutely unknown so far as actual service is concerned.

By the time these notes are in print, at least six of our principal railways will have compounds at work, and the evolution of the movement seems likely to proceed on the lines of continuous development in the same direction as time goes on.

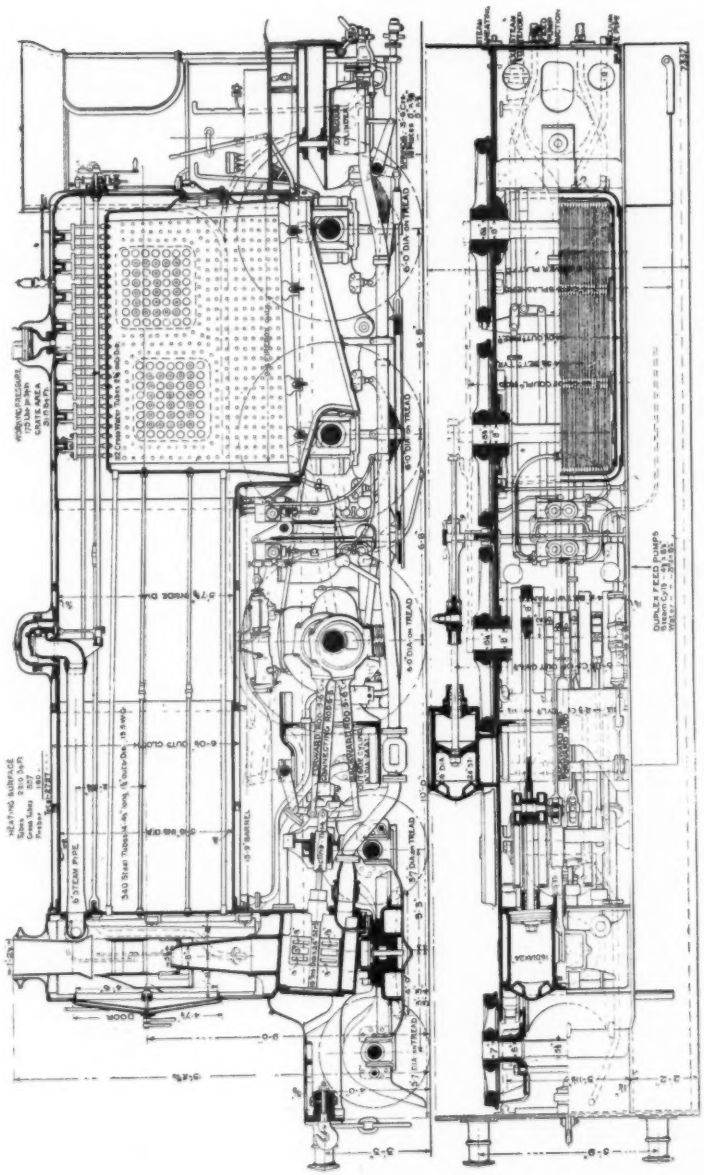
Those who are acquainted with the conditions under which the most important main line traffic is conducted, and who have had actual and extended footplate experience with single expansion locomotives, find it difficult to follow the reasoning of others who attribute the success of compound locomotives in France and on the Continent generally, to the increased boiler power, and the arrangement of the cylinders "apart from the compound principle." Assuredly the success of any locomotive intended for working under maximum conditions of service is materially added to by the provision of ample boiler power, and the arrangement of the cylinders is of itself secondary in importance when compared with the method adopted for the distribution of steam to them—a vastly different matter. To state, as some do, that the same power at high speed can be got out of a simple locomotive using an 18-in. cylinder, as out of a compound using larger cylinders, is tantamount to asserting that locomotives of greater power than those having 18-in. cylinders have become unnecessary; and that we know is not the case. The point we have to consider is:—What is the power required at starting and on heavy grades? An 18-in. cylinder is of course not large enough for the needs of the heaviest modern traffic at these times, and whatever virtues this particular dimension may possess at high speed, it is certainly insufficient at periods of stress with the modern heavily weighted trains, unless, of course, one is prepared to follow the Great Western lead, and adopt an unusual length of piston stroke as an off-set to the relative smallness in the diameter of the cylinders.

It is not, however, so much a question of power development—everything that is required and a good deal to spare can be accomplished by suitably proportioned simple locomotives if that were all—as of economy in steam consumption. A large cylinder capacity we must have nowadays, and yet a means must be devised for keeping in check the rate of steam consumption. What better plan of accomplishing this could there be than that of employing locomotives which are adapted for variable working at will, viz., as a simple or as a compound, to meet the varying conditions of service.

Under circumstances calling for the development of extreme power such as at starting and on heavy grades, the engine can be worked "simple" by admitting boiler steam direct over the combined area of the pistons, but under more favourable circumstances let it by all means work compound and thus reduce for as long a time as possible the strain thrown upon the generating power of the boiler.

Judging by present indications, we may certainly expect to witness an extended use of the compound locomotive being made in this country, not necessarily in any of its existing forms, but embodying, nevertheless, in one way or another, the principle of multiple expansion of steam.

The New Four-Cylinder Locomotives on the London and South-Western Railway.—The November Notes, as will be remembered, contained a photographic reproduction of engine No. 330 on the London and South-Western Railway, the first of a new series of four-cylinder simple locomotives, with six coupled wheels, designed by Mr. Dugald Drummond, Chief Mechanical Engineer, for working heavy passenger trains in the west of Salisbury districts.



NEW FOUR-CYLINDER LOCOMOTIVE, LONDON AND SOUTH-WESTERN RAILWAY.

The sectional elevation and plan drawings reproduced herewith clearly show the details of the design, and it will be recognised on examining these that Mr. Drummond has succeeded in mounting a very large and well-arranged boiler over what is—for a six coupled engine of the 4-6-0 type—a moderate length of wheelbase. Of course the comparative smallness in diameter of the coupled wheels is a factor which assists towards keeping the wheelbase down, but on the other hand the presence of two pairs of cylinders, one inside the frames and the other outside, arranged for driving separate axles, tends to balance matters in this respect. The heating surface of 2,727 sq. ft. is admirably disposed, the fire tubes being relatively short, whilst full advantage is taken of the heat imparted by the furnace gases when the latter are at maximum temperature, by providing two groups of water tubes, aggregating 112 in number, across the firebox. The smoke box contains Mr. Drummond's well-known spark-arresting and fuel-economising device, the efficiency of which has been amply proved. No injectors are used on these engines, the boilers of which are fed by two steam feed-pumps of the duplex type, placed under the boiler in the position shown, viz., over the axle of the front driving wheels. The feed water is heated by means of the apparatus devised by Mr. Drummond for the purpose.* By the aid of this device the feed water can be brought to a temperature of over 200° before it enters the boiler, so that we may take it for granted that it is practically impossible to use injectors. Everything has been done in this design not only to ensure the production of steam in ample volume, but also to secure reasonable economy in its consumption; a by no means easy matter with such a large total cylinder capacity, fed direct from the boiler.

The cranks on the front coupled axle are, as will be seen, of the balanced type, there being no weights in the wheels themselves. The stresses are kept more nearly in line by constructing the axle in this way. The crank-axle is built up instead of being machined from the solid, and the webs are in one piece with the balance weights. The throw of the cranks is 12in., but that of the coupling-rods is only 10in., the crank-pins and coupling-rod pins for the outside cylinders are in one piece, but are turned to different diameters, with 2 in. of eccentricity.

For the convenience of readers, the dimensions given in the November, 1905, issue are repeated herewith, together with additional particulars relating to the new engines, which it is understood will not be placed on regular service before the summer of the present year:—

Cylinders:—

Number	4
Diameter of each	16 in.
Stroke of pistons	24 in.
Distance between centres of inside cylinders	2 ft. 3 in.
Distance between centres of outside cylinders	6 ft. 11½ in.

Wheels:—

Number	10
" of pairs of driving wheels	2
" " " " wheels coupled	3
Diameter of driving-wheels on tread	6 ft.
" " bogie-wheels "	3 ft. 7 in.
Rigid wheelbase	13 ft. 4 in.
Bogie wheelbase	6 ft. 6 in.
Total wheelbase of engine and tender	52 ft. 2 in.
Total length of engine and tender over buffers	62 ft. 9½ in.

Boiler:—

Diameter of shell inside (maximum)	5 ft. 7⅞ in.
Length of barrel	13 ft. 9 in.
" " firebox	9 ft. 6 in.
Height of centre above rail	9 ft.
" " top of chimney above rail	13 ft. 2½ in.
Number of fire-tubes	340
Diameter of fire-tubes	1⅞ in.
Length of fire-tubes	14 ft. 4½ in.
Heating surface of fire-tubes	2,210 sq. ft.
Number of water-tubes in fire-box	112
Diameter	2⅜ in.
Heating surface of water-tubes in fire-box	357 sq. ft.
Heating surface of fire-box	160 sq. ft.
Total heating surface	2,727 sq. ft.
Grate area	31·5 sq. ft.
Working pressure	175lb. per sq. in.

Feed Pumps (Duplex Type):—

Diameter of steam cylinders	4½ in.
Stroke of steam cylinders	8½ in.
Diameter of pump cylinders	3⅜ in.
Stroke of pump cylinders	8½ in.

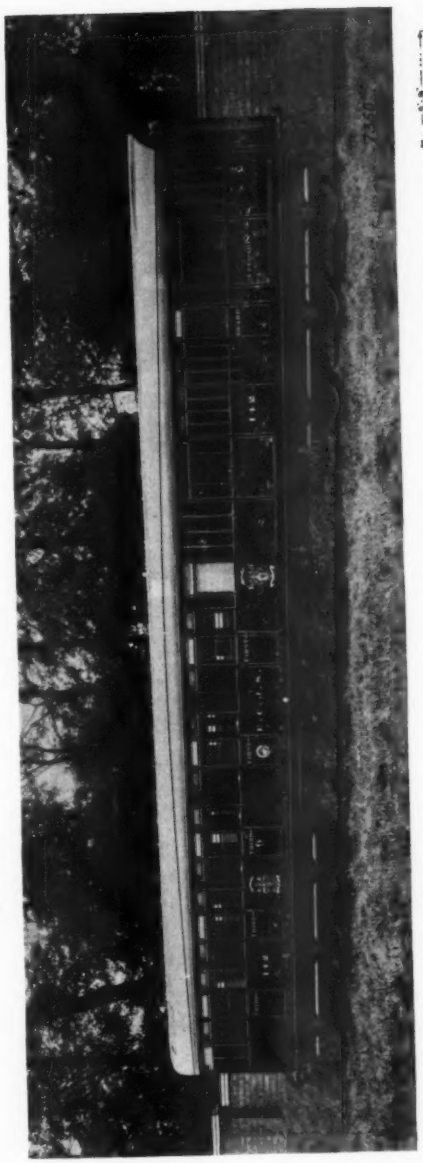
Weight of Engine in Working Order:—

	Tons.	Cwts.
On front driving-wheels	17	10
On back " "	17	10
On trailing-wheels	16	10
On bogie	21	10
Total	73	0
Tractive force on rails	18,700lbs.	

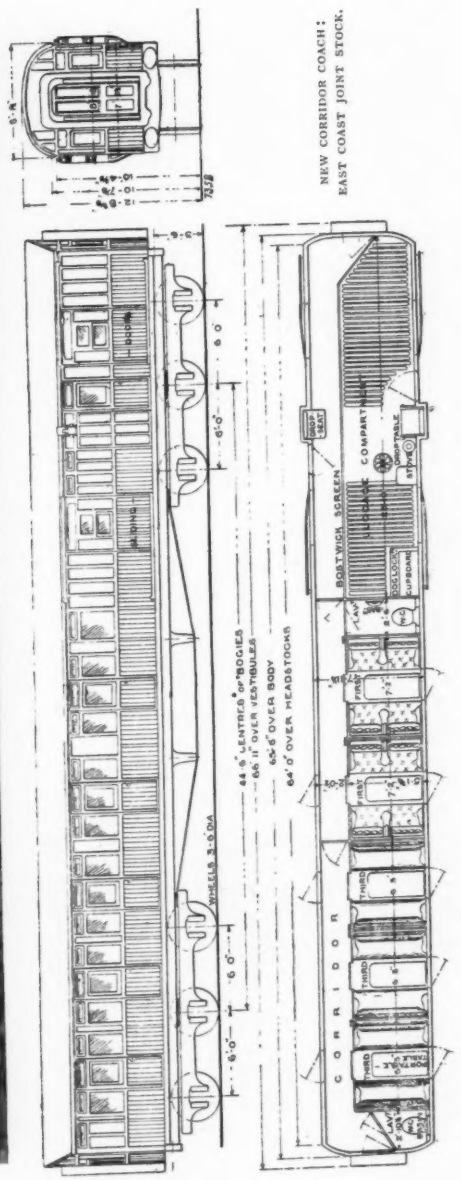
Tender:—

Capacity of tank	4,000 gallons.
Coal capacity	4 tons.
Heating surface in tubes in tender-well	382 sq. ft.

* An illustrated description of this appeared on page 341 of THE ENGINEERING REVIEW for April, 1904.



NEW CORRIDOR COACH: EAST COAST JOINT STOCK.

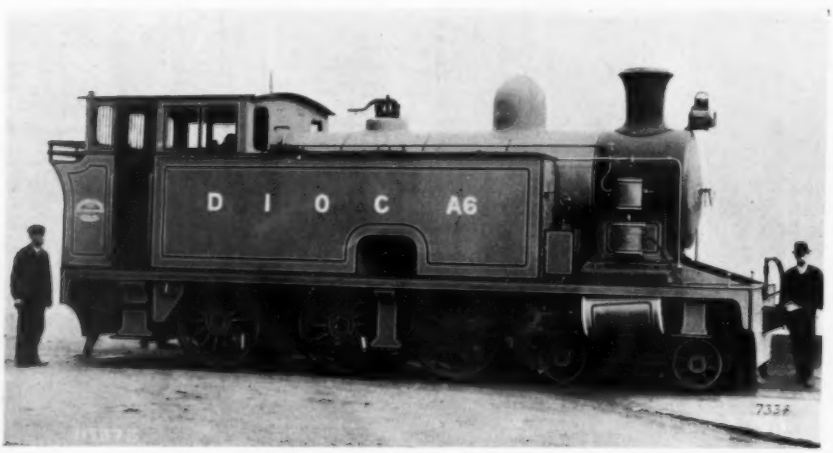


American Locomotives in Japan. — According to report, serious complaints are being made by the Japanese authorities about the locomotives supplied by firms in the United States for service on the Imperial Government railways. An official statement is to the effect that trouble has arisen from the faulty construction of the engines, which are alleged to have been fitted with leaky boilers, and to have imperfectly fastened rivets, whilst not one of their number could be passed out on to the line until a visit to the repairing shops had been made. It is further stated that the general construction of the locomotives is inferior, and to make matters worse the packing had been done in such a careless manner that damage to the parts in transit followed as a matter of course.

END VIEW OF NEW CORRIDOR COACH, EAST COAST JOINT STOCK.

How far these allegations are justifiable or otherwise we are not in a position to judge. Those who have had an opportunity of examining the work turned out of locomotive shops in this country for foreign destinations will, however, know that charges of the nature of those above could never truthfully be brought against British manufactures of a similar kind. We may take it for granted that during the next few years a large number of new locomotives will be required in Japan, and as the majority of these will come from outside we may hope that the Japanese officials will be guided by their experiences when placing their orders.

Latest E. C. J. S. Coaching Stock.— The accompanying photographic reproduction shows the latest type of corridor coach designed by Mr. Wilson Worsdell, M.Inst.C.E., Chief Mechanical Engineer of the North-Eastern Railway, for the East Coast Scotch Express services.



4-6-0 TYPE TANK LOCOMOTIVE BY MESSRS. ANDREW BARCLAY SONS & CO., LTD., KILMARNOCK

The coach illustrated, which is of the composite type, was built at the company's carriage works at York in November last, and is of entirely new design, the sides being perfectly straight with narrow slips on the lower portion without panelling. An elliptical roof is substituted for that of the clerestory pattern common in other East Coast Joint Stock vehicles, the roof being carried to the extreme height allowed by the loading gauge.

There are two first class and three third class compartments, providing accommodation for eight first class and eighteen third class passengers, or twelve seats when dining. A corridor runs along one side of the vehicle with three doors for entering and leaving the coach.

The van portion is fitted with "Bostwick" collapsible gates by means of which the luggage may be screened off and a continuous corridor throughout the train formed. Steam heating and incandescent gas lighting are employed in this coach. The underframe is of the standard East Coast pattern constructed of steel with truss bars and transverse girders as pedestals. Buck-eye automatic couplers and Pullman vestibules are fitted, and the principal dimensions are as follows:—

Length over vestibules	66 ft. 11 in.
" " body	65 ft. 6 in.
" " headstocks	54 ft.
Total width of carriage	7 ft. 11½ in.
Bogies (type)	6 wheel.
Diameter of wheels	3 ft. 6 in.
Wheelbase per bogie	12 ft.
Distance from centre to centre of bogies	44 ft. 6 in.
Rail lever to top of roof	12 ft. 8⅞ in.
Weight of carriage empty	37 tons.

Powerful British-built Tank Locomotives for Service Abroad.—The accompanying photographic reproduction illustrates a handsome 4-6-0 type tank locomotive built by Messrs. Andrew Barclay Sons & Co., Ltd., of Kilmarnock, N.B., for hauling materials at the mines of the Dunderland Iron Ore Company to and from the port of Guldsmedvik, in Norway. Two engines of this design have been supplied, and they rank among the largest and most powerful yet constructed at Messrs. Andrew Barclay Sons & Co.'s works, indeed they may be said to have a special character of their own among locomotives intended for service of the description referred to, both as regards the wheel arrangement employed and also in respect of many of their proportions.

The cylinders are placed outside the frames at the bogie centre; they are inclined and drive the intermediate pair of coupled wheels, the axle of which is located just in front of the fire-box. The valve-gear, which is of the ordinary link-motion type, is inside the framing, and a clearance is provided in the side tanks for rendering the gear accessible from outside for the purpose of oiling. The boiler is proportioned in accordance with the rest of the design, and is built up of Siemens-Martin acid steel plates $\frac{9}{16}$ in. thick. It is 4 ft. 5 in. in diameter, and contains 194 tubes 1¾ in. diameter by 11 ft. long. These contain 977·6 sq. ft. of heating surface, to which is added 95 sq. ft. contributed by the fire-box; a total of 1072·6 sq. ft. The grate area is 16 sq. ft. and the working pressure 160 lbs. per sq. in. The cylinders have a diameter of 18 in. and a piston stroke of 26 in.; the coupled wheels are 4 ft. 2 in. diameter on tread arranged on a wheelbase of 10 ft. 6 ins., whilst the bogie wheels are 2 ft. 3 in. diameter and the total wheelbase 20 ft. 1½ in. The bogie has 3 in. of side play. The engines have a tank capacity of 1,500 gallons, and weigh 58½ tons in working order. The boiler is fed by two No. 8 "Sirius" injectors by Holden and Brooke, and the other equipment includes Westinghouse quick-acting brake appliances (with 15 in. cylinder) and M.C.B. couplers of the "Janney" type. The workmanship and material are throughout of the best quality, and both will worthily reflect the high standard of the builders abroad.

The New Great Central Route to London.—The new Great Central Route to the Metropolis via Grendon-Underwood, Princes-Risboro,* High Wycombe* and Northholt, has now been in operation for goods traffic for upwards of two months. Although the distance from the north to London by this route is slightly longer than that *viâ* Quainton Road and the Metropolitan Railway, the better facilities offorded for uninterrupted running will be all to the advantage of the company in conducting an improved service of trains. This time they have at disposal as fine a stud of locomotives as could be wished for, which is more than could be said at the time of the opening of the original "London Extension."

* Great Western and Great Central Joint Railway, see THE ENGINEERING REVIEW for September and October, 1903.

Automobile Engineering Notes.

BY ROBERT E. PHILLIPS, M.I.MECH.E., A.M.INST.C.E., A.I.E.E.

Now that the Olympia Show is a thing of the past one is able to see the present trend of design which can be summed up as "Refinement in details of construction while adhering to established lines and principles." Dealing first with the pleasure vehicles. It is apparent that more attention has been given to the "springing" of the cars, In many instances semi-elliptical springs replace the rigid dumb irons, and in some instances Cee springs have been introduced, not only on the chassis, but also between the body and the chassis, while the application of check springs to prevent the rebounding action when travelling over very rough roads is becoming more general. It is also noticeable that larger wheels are being used and, what is more important, larger pneumatic tyres. A very great deal of the trouble arising from tyres can be obviated by using a larger and heavier type. The increased initial cost is saved several times over in the long run. The proportion of covered in or protected bodies is greater than ever, and points to the more practical use of the motor car. One of the most striking departures is the three-seated landaulette by Messrs. Mulliner's Carriage Building and Motor Co., Ltd. The third seat inside is obtained by making use of the space beside the driver's seat and building it into the body of the landaulette. The side entrance body is for all but small cars, entirely superseding the tonneau body, though the extra length of chassis which the side door necessitates may often well be dispensed with by utilising the side entrance to the front seat by swinging or folding one half of this seat. The pressed steel frame is fast superseding all other types, but, in this as in other things, manufacturers are too prone to copy without first satisfying themselves that it is the best type to employ. An exception is the frame of the Daimler Co. This is built up of angle iron, and is not only lighter than the average pressed steel frame, but is immeasurably stiffer against torsional strains. The result is so different from what one would expect by merely looking at these two types of frame, that it is only by actual experiment that the enormous difference in stiffness can be appreciated. In the larger chassis the front ends of the frames are narrowed to give an increased lock to the steering wheels. This is a step in the right direction, as the excessive length of some cars makes them very awkward to handle in crowded thoroughfares. The secondary frame appears to be passing away, as in all the larger types of cars both the engine and the gear box are attached to, and carried by, the main frame. It is also interesting to note the increase in the use of protective aprons, as these not only protect the machinery from dust and dirt, but also, if properly arranged, have material effect in reducing the dust-raising propensities of a car. A novelty in frame construction was shown by the Simms Manufacturing Co., Ltd. The main and secondary frames are pressed out of sheet steel, the one edge of which is of an L-shape reinforced or filled with a wooden beam forming the main frame, and the other edge for a portion of its length, which is of a U-shape, forming the underframe, the part of the sheet connecting the two edges forming a very efficient dust screen. One of the points brought out by the show was the tendency to increase the number of cylinders. Quite a large number of makers are following the example of Napier in using six cylinders, and one firm has gone one better and is employing eight cylinders. Although an engine with this number of cylinders has been used experimentally in motor car construction before, this is the first attempt to employ that number commercially. The engine to which we refer is used in the Rolls-Royce "Legalimit" car, which is designed to maintain, but not exceed, the legal limit of speed up hill and down dale. There are many novel details in the construction of this engine which cannot be dealt with at length now, but we shall return to it at a later date. The practice of casting the cylinders together seems to be on the increase, and points to the fact that the foundry work is becoming more reliable than in the past. Two notable examples were the four-cylinder engine of the 10-14 h.-p. "Renault" and the four-cylinder engine of the 10-12 h.-p. "Rover." In the former the induction and eduction ports or passages for the several cylinders are formed in the casting itself, so that there is but one joint to make for the inlet and exhaust respectively. In the latter not only are the four cylinders in one piece, but they are integral with the top half of the crank chamber, the whole being so arranged as to present a rectangular exterior shape, the chamber for the valve mechanism being covered by an easily detachable plate. As regards valve mechanism the over-head motion and inverted valve seems to be on the decline, as also is the variable lift to the inlet valves. Whilst the former has sufficient advantages to justify the increased number of working parts its use involves, the advantages that the latter gives over a well designed throttle valve exist more in theory than in practice, and appear insufficient to justify the increased complication it involves. The only novelty in valves and valve gears was the Auto-Mechanical inlet valve fitted to the engines of the Duryea cars. As this new valve will be dealt with at length in a future article it will suffice to remark that the mechanical pressure, instead of operating to open the valve, merely operates to remove the pressure of the spring from the valve in advance of the time the valve should open, so that it is kept on its seating during the latter part of the exhaust stroke

by the pressure in the cylinder, and is therefore free to open immediately the pressure in the cylinders falls to atmospheric pressure. It is thus claimed that the advantages of both the atmospheric and mechanically operated valves are obtained without any of their disadvantages. Magneto ignition is more generally used, the popular system being the high-tension, and where high-tension ignition by accumulator and coil is used on cars having engines with a plurality of cylinders, means are employed to synchronise the time of ignition. This is undoubtedly a step in the right direction, but manufacturers have been a long time adopting it having regard to the fact that its advantages were pointed out and demonstrated at least six years ago; but history is only repeating itself in showing up the deep-rooted conservatism of the British manufacturer. Many cars having magneto ignition are provided with a secondary system of ignition to facilitate starting-up and as a stand-by. Where the standard ignition is high-tension magneto and the auxiliary ignition is high-tension by accumulator and coil, the distributor of the magneto is used also for the auxiliary ignition, which tends to simplicity. Although the leather faced coned clutch seems to be holding its own the multiple disc type is employed in many cars, and of this type the Hele-Shaw and the Bradley appear to find most favour. The Sparks-Boothby hydraulic clutch first shown at Olympia last year is now fitted to the new Morgan chassis. This is of such a novel construction that we propose to describe it in detail in a future issue. Water circulation by the thermo-syphon system appears to be on the increase, and when properly designed and carried out seems to give such good results that the use of a pump becomes questionable. It is, however, interesting to note that, in nearly every case where this system is employed, a fan is used to increase or assist the circulation of air through the radiator. The honeycomb type of radiator first introduced on the "Mercedes" car appears to be falling into disuse, probably from the trouble many radiators of this type have given due to their leaking proclivities. The grilled tube radiator built up in combination with a surrounding water tank is quite as effective as the honeycomb type, and is certainly more reliable and less likely to become damaged or disarranged. In change speed gears there is very little departure from existing practice. Ball or roller bearings are now being largely used and a direct drive is given on at least one speed, and that not always the top one. The gear box of the "Philan" car is noticeable by reason of its giving a direct drive on two of the speeds, and it is suggested that in a later type a direct drive will be given on all speeds. Transmission by propeller shaft and live axle is fast succeeding the chain-drive, and many practical improvements were observable, notably in the universal joints in the propeller shaft, in the construction of the live axle, and in the casing in of the joints of the propeller shaft. It is becoming a recognised practice in live axle construction to carry the driving wheels on hollow stud axles so as to relieve the driving axle of all work other than transmitting motion to the wheels. The most daring innovation in this type of transmission is the universal joint of Legros and Knowles, which we shall deal with when describing the "Iris" car manufactured by this firm. The petrol engine is now made so flexible and silent that its use as the propulsive agent of motor cars for town use is greatly on the increase, and unless the electrically propelled vehicles make more advanced strides than they have in the past they will be driven from popular favour by the petrol-engined car. The one great drawback to the use of the petrol engine for town cars has hitherto been the large proportion of the length of the frame that has been taken up by the engine, thereby either cramping the body room or necessitating a long chassis, which makes for inconvenience in handling the car in street traffic. So far, the makers of cars with horizontal engines have scored, as the position of such engines enables the driver's seat to be brought right forward over the engine. An example of this was seen in the landaulettes of Messrs James and Browne, Ltd, which with their swan-shaped dashboards so nearly resemble the electric carriages of the Electromobile Co. that it takes an expert to discern the difference, not only in appearance, but also in running. These carriages have been fitted for some considerable time past with a device for starting the engine from the seat, which is very interesting in view of the fact that our friends on the other side of the water are only just waking up to the fact that such a contrivance should be a *sine quâ non* on town carriages, as is instanced by the competition for such devices recently held by the Automobile Club de France.

Commercial Vehicles.—As regards commercial vehicles, with but a single exception there was a complete absence of experimental machines, which may be regarded as a sign of the growth of the industry dealing with this class of vehicle. A noticeable feature is the good workmanship shown in nearly every case, and this may be taken as an indication that manufacturers realise that to be successful in this branch of the industry nothing but the best workmanship and material will suffice. Not the least important part of a commercial vehicle are the wheels, and, although wooden wheels of artillery type are most generally employed, some firms are using cast-steel wheels, the behaviour of which will be watched with interest, but whether this construction is superior to wheels built up of dished plates remains to be seen. The question whether wheels should be dished or not still remains a moot point. Although some of the wheels shown —generally the driving wheels—are slightly dished, this construction seems to have been designed rather to enable a wide tyre to be used while not unduly overhanging the end of the axle carrying the wheel than to increase the lateral stability of the wheel. The question of tyres

will always be an important one, and while an elastic tyre of some sort appears to be a necessity in the case of passenger vehicles, unyielding tyres seem to be sufficient for freight vehicles; whether anything better than the iron tyre will be found satisfactory time alone will show. It is, however, interesting to note that one vehicle had its wheels shod with tyres composed of wooden blocks. As to "keep running" is the essential in a passenger vehicle, any means for rapidly removing and replacing a worn out elastic tyre should prove advantageous. To this end many tyres are built up of segmental parts, and in some instances each such part can be detached without disturbing the other parts of the tyre. In another construction the tyre is mounted on a rim which is capable of being readily attached to, or detached from, the rim of the wheel as a whole. The system of transmission that seems to find most favour is by a propeller shaft from gear box to differential axle and from differential axle to driving wheels by chains. In some instances the transmission is made elastic within certain limits to enable the load to be picked up gradually, which seems a step in the right direction having regard to the carelessness of the majority of drivers. A novel form of reduction gear is employed by Messrs. James and Browne, Ltd., by which they are enabled to employ a standard type of gear box, and at the same time to vary the ratio of the gearing between the differential axle and the road wheels without altering the sizes of the sprocket wheels to suit the particular work the vehicle is intended to perform. The steam vehicles with one exception present no novel features, the exception being the "Hay" motor, the design of the engine and transmission gear of which embodies some ingenious ideas about which we prefer to withhold an opinion until the vehicle has undergone a more extended trial. The engine, which has a single cylinder, runs at slow speed and is fitted with a variable cut-off gear. The transmission is by means of a pair of connecting rods operating the two-part back axle by means of ratchet and pawl gear.

The "Mechanical World" Pocket Diary and Year Book for 1906. Manchester, Emmott & Co., Ltd. Price 6*d*. net. In the nineteenth annual issue of this useful pocket book a large amount of new matter has been introduced relating to branches of engineering practice which are becoming increasingly important. In a section of ten pages will be found a succinct and practical account of the Steam Turbine, together with a deal of practical data and information on the subject. Other new sections deal with refrigerating machinery, ice manufacture, and cold storage, speeds and feeds suitable for high-speed steel tools. A new and much enlarged table of factors of evaporation has been introduced; while additions have been made to the sections dealing with gas and oil engines.

Metallurgical Progress.

BY PERCY LONGMUIR.

The British Foundrymen's Association.—A report of the proceedings of this association has just been issued, and it includes the papers read at the second annual convention at Glasgow in the early part of last August. The report is of special interest to foundrymen, and an association of this character, established for the study of foundry practice and the promotion of foundry knowledge, is of value not only to founders but equally so to all users of castings. Turning to the papers we note first the presidential address of Mr. Buchanan, which admirably summarises many salient features of foundry practice. At the outset the objects of the association are shown to lie in the consideration of practical and scientific questions pertaining to the industry represented. The effect of external influences is indicated, and their value shown to lie in the assistance given to the founder for better and more accurate means of production. It is therefore well to keep an open mind, ready to receive improvement from whatever source it comes, having learnt by experience to winnow the chaff from the grain. Whilst present prospects indicate no startling advance in the casting of metals, it is nevertheless not too much to say that if every British foundry possessed at least one man abreast of the scientific and metallurgical knowledge applicable to his business, that in itself would constitute an advance equal to anything yet witnessed either in the foundry or other industry. Practical work to be of the best kind must necessarily be scientific, and actually there should be no divorce between the two in that science is knowledge reduced to a system. In commenting on matters of management, the president specially emphasises the need for adequate supplies of tools to the moulders and the provision of suitable shop tools. In this respect, what is wanted is the application of common sense mixed with some business knowledge, a remark especially applicable to all phases of foundry management.

Technical Education for Foundrymen.—This paper, by Prof. Sexton, follows the presidential address, and contains much of value applicable to the technical training of moulders. The author, with justice, emphasises the necessity for preliminary education before taking up purely technical work. Suitable training and its advantages to the recipient and his employer are fully indicated.

Cast Iron.—The second paper, by Mr. Pilkington, M.Inst.C.E., M.Inst.M.E. is an admirable one, and the author does very full justice to his subject. At the outset, the necessity for careful and intelligent mixing and melting is emphasised, and characteristic features of different foundry irons are indicated. The constituents present in an iron should be ascertained by analysis and carefully studied with regard to the ultimate use of the iron in

the various classes of castings made. These constituents have a very considerable influence on the resulting metal, more especially with regard to strength, fluidity, hardness or softness, waste in remelting and consumption of coke in the cupola. Probably two of the best foundry irons in this country to-day are Scotch and Derbyshire, which have a manganese content of one per cent. or over. Whilst manganese undoubtedly weakens and hardens cast iron, it must be remembered that in remelting much of the manganese is lost, and this loss means a loss of sulphur also. Manganese has often been used in chilled work where it is entirely out of place, and can only tend to weaken the chill if used in amounts over one per cent. The best practice is found with a content of under 0·7 per cent. Sulphur may be present in chilling irons, as in No. 5 Staffordshire cold blast, to the extent of 0·15 per cent. without any ill effect. Silicon in iron for chill roll making varies from 0·8 to 1·0 per cent., and with silicon so low, the foregoing amount of sulphur doubtless has some effect on the state of carbon. This class of irons, i.e., for chilling, usually average about 0·5 per cent. phosphorus, and the resulting castings possess good transverse and tensile strength, and whilst hard to machine, are when machined exceedingly sound and clear. The advantages of melting in an air furnace for chilled work lie in the higher temperature, more efficient mixing and absence of contamination.

The cupola is not an efficient mixer, and, owing to contact of metal and fuel, sulphur is always taken up. It is, therefore, important that a coke low in sulphur should be used; actually 1 per cent. is a danger limit, and even this is too high when really soft castings are desired. Sufficient lime should be used in the cupola with sufficient manganese in the charge, and, above all, hot melting should be the general practice. Where the cupola charge consists of two or three brands of iron it is important that the metal be collected in a receiver or large ladle, in which the metal can cool to the required casting temperature. This plan facilitates mixing and favours the production of clean, sound iron.

Much discussion has been given to grading by analysis, but it is noticeable that casting machines for foundry iron make no headway in this country. Where mechanical handling is followed the metal is cast in sand, lifted by cranes and broken by machines. This is done to preserve the fracture, as buyers will not take iron from casting machines owing to the broken, chilled or scattered fracture caused by casting in iron moulds. This may be prejudice, but the author is of the opinion that silicon alone is an unsafe guide to the grading character of foundry pig iron without the assistance of fracture. The fact is that the fracture shows that the carbon is either in a normal or an abnormal condition, and that is of value in itself.

In concluding the paper the author records a series of most interesting experiments on the further treatment of grey iron. This treatment may be described as rapid cooling through a certain range of temperature. For example a series of bars plunged at a cherry-red heat into a blacking bosh and maintained there for a little over a minute and then naturally cooled were found to increase considerably in transverse strength. Thus, in round numbers, a breaking load of 28 cwts. in the untreated bars was raised to one of 38 cwts. in the treated bars. Owing to the short time of immersion and also owing to the fact of the bath being practically a thin mud bath, the cooling is of a negative character. Subsequent experiments, recorded in the following table, show the most effective temperature for maximum strength to lie in the neighbourhood of 1,300° Fahr. Quenching at higher or lower temperatures diminished the strength, an effect also noted with absolute quenching.

HEAT TREATMENT OF TEST BARS.

No. of Test.	Character of heat treatment.			Analysis after treatment.						Mechanical test.				
										Transverse tests. Size 36 in. by 1 in. by 2 in. deep.				Tensile tests. Size 1¼ in.
										Strength.			Defl.	Strength.
	Temperature when dipped.	Temperature when taken out of bath.	Time occupied in dipping.	Graphite carbon.	Combined carbon.	Silicon.	Phosphorus.	Manganese.	Sulphur.	Cwts	qrs.	lbs.	ins.	Tons per sq. in.
1	Untreated, cooled in box.			2·85	0·58	2·175	1·337	0·085	0·058	28	2	12	·347	10·34
	°F	°F												
2	900	500	1¼ min.	3·00	0·45	1·960	1·441	0·790	0·050	25	3	0	·320	9·41
3	1,000	505	,,	2·88	0·52	1·960	—	—	—	22	0	9	·305	9·66
4	1,100	500	,,	2·88	0·49	2·025	—	—	—	32	0	20	·438	10·32
5	1,200	510	,,	2·87	0·48	2·025	1·441	0·840	0·052	31	3	18	·393	9·89
6	1,300	505	,,	2·94	0·50	2·025	—	—	—	31	1	24	·400	9·94
7	1,400	505	,,	2·94	0·51	2·025	—	—	—	35	3	20	·455	10·28
8	1,520	510	,,	2·90	0·60	2·025	—	—	—	under 16 cwts.			·240	9·38
9	1,600	510	,,	2·84	0·68	2·025	—	—	—	,,	12	,,	·122	5·45
10	1,700	510	,,	2·87	0·68	1·960	1·367	0·770	0·051	,,	12	,,	·190	broke

Fire-clays and Moulding Sands.—The third paper by Mr. P. Longmuir deals with fire-clays and moulding sands as used in foundry practice. The range of temperature which the linings of a foundry furnace have to resist vary somewhat as follows :—

Crucible for brass	1200 to 1400°C.
Air furnace for brass	1200 to 1400°
Cupola for iron	1500 to 1600°C.
Air furnace for iron	1550°C.
Crucible furnace steel ...	1650 to 1700°C.
Open hearth furnace steel ...	1700 to 1800°C.

Mould temperatures vary, but under normal conditions will be found as follows :—

Aluminium	690°C.
Ordinary casting brass	970°C.
Yellow metal	1020°
Gun metal	1070°
Brazing metal	1080°
White cast-iron for malleable	1230°
Grey cast-iron	1350°
Pure iron, 0·08 per cent. carbon ...	1650°
Steel, 0·3 per cent. carbon	1600°
Steel, 0·37 per cent. carbon	1550°
Steel, 0·5 per cent. carbon	1500°

These tables show the higher range of furnace temperatures and give an index as to one essential requirement in both linings and sands. Apart from resistance to heat furnace linings have other requirements to meet, found for the most part in (1) expansion and contraction due to alternate heating and cooling ; (2) the cutting action of flames, the abrading action of molten metal, and the searching action of metallic oxides or scouring slags ; (3) reducing or oxidising atmospheres in the furnace ; and (4) mechanically the lining must withstand the wear and tear of charging solid metal. The various materials in use to meet these requirements are indicated at full length, and analyses are given of the various refractory materials. Turning to moulding sands, which, owing to their high content of silica may be described as acid refractory materials, it is noted that generally they have the same requirements to meet as have furnace linings. But in the case of a sand these requirements are, if anything, accentuated and others are introduced. A moulding sand should, with the minimum of trouble, produce a clean casting, which involves that the metal poured into the mould shall not soften or fuse the sand. If temperature were the only consideration it should follow that the higher the content of silica in the sand the greater the heat-resisting property. That is, moulding sands could be classified somewhat as follows :—

Type of casting.	Brass.	Light cast-iron.	Medium cast-iron.	Heavy cast-iron.	Steel.
Content of Silica	78 to 80	80 to 82	82 to 84	84 to 88	90 to 95 %

This classification cannot, however, be taken as a hard and fast rule, and, quite apart from temperature, the *searching* action of liquid metal must be considered. This feature is illustrated by quoting examples from lead, cast iron and steel, which show that searching is determined by fluidity and pressure rather than temperature. The fact that alumina increases the binding properties of a sand permits of another form of classification, thus :—

Type of casting.	Light brass.	Heavy brass and light iron.	Medium iron.	Heavy iron.
Content of alumina	12	10	8	6%

To put this table in another light, clay water is often added to a sand lacking "grip." This addition of clay water adds alumina to the sand, thereby increasing its binding properties. Actual analyses of moulding sands are as follows :—

Analyses of Sands.

	Black.	Mansfield.	Kidderminster.	South Staffords.	Glasgow Building Chips.	Clyde Rock.
Silica	78·5	83·40	83·69	85·52	92·75	87·32
Ferric Oxide ...	6·0	3·14	4·10	3·72	2·50	3·74
Alumina	4·75	7·47	6·26	5·47	2·56	7·10
Lime	0·3	0·20	0·66	0·74	0·27	0·64
Magnesia... ...	—	0·62	0·51	0·52	Trace	0·31

The Microstructure of Pig-Iron.—The fourth paper by Mr. A. Campion, F.I.C., F.C.S., deals with the structure of pig-iron, and is illustrated by means of a number of photomicrographs. Methods of polishing, etching and heat tinting sections are indicated and the chief constituents of pig-irons described. Practically a grey iron may be regarded as a dead soft steel with graphite plates scattered through the mass. A close grey iron consists of graphite, pearlite and ferrite, whilst a mottled iron may be compared with a high carbon steel plus some graphite. Typical photomicrographs illustrate the various structures described.

National Founders Association.*—At the New York meeting of this Association, one of the papers of a purely technical character was on machine moulding. Mr. A. J. Caldwell, in introducing the subject, drew a distinction between moulding by machine and machine moulding. Machine moulding proper is defined as any method which takes one or all of the operations from the hands of the operative and places it upon a mechanical basis. The precise method must be determined by the

* *Iron Trade Review*, Vol. xxxviii. No. 47.

class of work in hand, and whilst the chief question is "Does it pay well?" other considerations are to be found—for example, the question of output and the speed at which work can be passed through the shops, thereby effecting a saving of capital locked up in stock.

On the Composition of a Cast-Iron Bullet from the Moat of the Bastille.—Recently several cast-iron bullets have been found in the old moat of the Bastille, and an examination of one of them by Mons. M. A. Porlier is recorded in a late issue of the *Revue de Métallurgie*. The fracture presented a radial structure with a greenish yellow colour very dissimilar from that of cast-iron. The density of the bullet was 4·854, as compared with an average density in cast-iron of 7·6. Microscopical examination showed brilliant lines of cementite, which had completely preserved its metallic state. The black parts of the structure represent oxidised portions. On analysing the sample the following results were obtained:—

Water (by drying at 130°C.) ...	2·9	per cent.
Carbon	5·9	,,
Silicon	0·25	,,
Manganese	0·75	,,
Iron	72·00	,,
Oxygen by difference	17·45	,,

The high content of carbon is due to the fact that part of the iron has, by the formation of oxide, been forced to the outside, this being due to the volume of oxide exceeding that of the metal. The amount of oxygen confirms the micrographic observations, viz., that a part of the iron was oxidised but not the total. This oxidation in the heart of a bullet without external deformation or fissuration indicates an intervention of the phenomenon of diffusion.

Chemistry in Foundry Practice.*—Mr. C. Henning, in an address to the German Iron Founders' Association, discusses the application of chemistry to foundry practice. In particular we note that attention is drawn to special foundry irons of British origin which, owing to their fine grain, yield castings of high tensile strength. In these irons as used for cylinders and similar types of castings, silicon ranges from 1·0 to 1·4 per cent.; phosphorus between 1·0 and 1·65 per cent., and sulphur between 0·065 and 0·161 per cent. These figures are deduced from a series of British irons given, and in discussing whether these comparatively dear irons cannot be replaced by others of home production, the author quotes a series of analyses of German irons of Hematite and foundry quality from which the following are selected.

HEMATITE FOR CYLINDERS.

Aplerbecker Hütte.					Carl Später Koblenz.				
No.	Silicon.	Sulphur.	Manganese.	Phosphorus.	No.	Silicon.	Sulphur.	Manganese.	Phosphorus.
1	1·22	0·030			1	1·42	0·066		
2	1·17	0·028			2	1·19	0·058		
3	1·13	0·039	1·08	0·07	3	1·31	0·055	0·88	0·08
4	1·10	0·039			4	1·15	0·062		
5	1·05	0·055			5	1·22	0·046		

FOUNDRY PIG IRON FOR CYLINDERS.

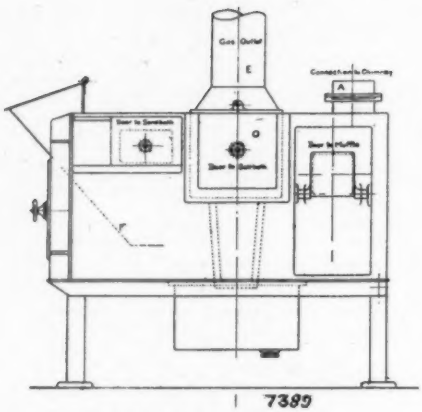
Concordia Hütte.					Schalker Gruben und Hüttenverein.				
No.	Silicon.	Sulphur.	Manganese.	Phosphorus.	No.	Silicon.	Sulphur.	Manganese.	Phosphorus.
1	1·3	0·070	0·78	0·81		1·66	0·024		
2	1·3	0·050	0·69	0·80		1·97	0·011		
3	1·2	0·065	0·76	0·81		1·79	0·013	0·69	0·68
4	1·3	0·066	0·68	0·85		1·78	0·013		
5	1·3	0·060	0·60	0·60		1·75	0·019		

However, apart from chemical composition, Rhenish or Westphalian irons are not sufficiently close in grain, and in castings do not yield the requisite tensile tests. The author draws from his examination of both types of iron that British varieties, in spite of variations shown in individual brands, are always relatively low in total carbon and comparatively high in combined carbon.

A German Furnace for Melting Lead or Salt for Steel Hardening.†—This furnace by Pekrun is a combination of melting pot for salt or lead; muffle for preliminary heating and a sand bath for drawing the

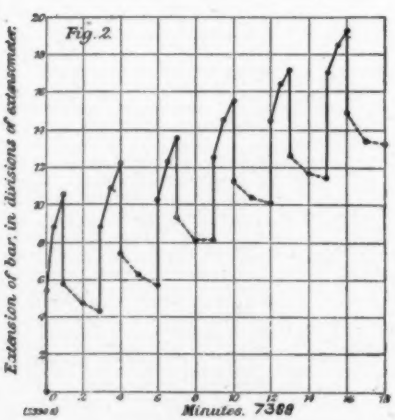
* *Stahl und Eisen*, Vol. 25, No. 21.

† (1) Robert Grimshaw, *The Iron Trade Review*, Vol. xxxviii. No. 46.



FURNACE FOR STEEL HARDENING.

temper. The appended sketch shows an arrangement of melting pot and muffles. The pot is fired from the grate F, and the products of combustion pass round the muffles before entering the stack. A hood is placed over the pot and may be led to the stack, thereby drawing away the fumes. The articles before immersion are heated to a black heat (150° to 200° C) in the muffle, thereby increasing the capacity of the hardening pot and at the same time preventing sputtering due to the immersion of a cold piece of steel. The sand bath is used for any tempering required after hardening.



ELASTIC PROPERTIES OF STEEL AT HIGH TEMPERATURE.

The Elastic Properties of Steel at High Temperatures.*—Professor Hopkinson and Mr. F. Rogers, in a communication to the Royal Society, record their investigations of the elastic properties of steel and iron at temperatures ranging up to 800° C. They find that as the temperature rises the stress strain relations undergo a remarkable change, which may be best expressed by stating that the "time effect" or "creeping" increases greatly with the temperature. In conducting the experiments the test pieces were placed in a vertical resistance furnace wound with three coils of nickel wire. The currents in these three coils could be separately controlled and an approximately uniform temperature thus maintained along the test piece. Temperatures were measured by means of thermo-couples placed one at each end and one in the middle of the test piece. An atmosphere of nitrogen was maintained in the furnace in order to avoid oxidation effects. The appended curve, Fig. 2, shows the results of tests on a steel bar at a temperature of 750° C. The bar was loaded with 85 lbs. for one minute, then unloaded for two minutes and so on, and the curve shows the resulting changes of length in terms of the time. During the times covered by the dotted lines the bar was unstressed. At this low stress, about 1¼ tons per sq. inch, the metal flows fairly rapidly, and overstraining has a considerable hardening effect, as shown by the diminishing amount of the permanent set produced by successive loads. This apparent hardening disappears with rest, and if the bar is left unstressed at 750° C. for two hours it is restored to its original soft state. Fig. 2 might, but for one remarkable difference, apply to a cold bar stressed to its yield point. The difference lies in the behaviour of the bar after the removal of the load. A cold bar does not contract appreciably; there is the instantaneous contraction, then it stops. On the other hand the hot bar goes on shortening for two minutes or more after the load is off, as shown by the dotted line on the diagram, and the total amount of such shortening amounts to roughly one-third of the instantaneous contraction, or one-quarter of the total contraction, or one-fifth of the average total extension after hardening has taken effect.

Nickel-Manganese Steels.—M. Guillet, in the November *Revue de Métallurgie*, records his examination of the properties of a series of nickel-manganese steels. The memoir is prefaced by a study of the theoretical constitution of these steels, and this aspect is summarised in general form by means of a triangular diagram, the apices of which correspond to carbon, manganese and nickel. Subsequent micrographic examination supports or approaches the results theoretically anticipated. Generally the steels admit of classification into three groups described as: (1) Pearlitic, (2) Martensitic, and (3) Gamma iron. Whilst all nickel

* *Engineering Record*, Vol. 52, No. 21.

steels or manganese steels examined by the author have all rolled easily, certain of the nickel-manganese steels could not be rolled. For example, the following steels would neither roll nor hammer :—

Carbon.			Nickel.			Manganese.
0·2	...	...	30	...	...	15
0·8	...	...	30	...	...	15
0·8	...	...	12	...	...	7
0·8	...	...	12	...	...	15

This fact is, according to M. Guillet, of interest in that the foregoing are all steels of "gamma iron," a feature which illustrates the variations possible in the properties of gamma iron "according to the bodies which it encloses in solution."

The mechanical properties of the three series of steels examined are embodied in the tables given below.

Quenching experiments on the foregoing steels show that the pearlitic class are converted into martensite, and by consequence yield higher elastic limits and breaking loads, lower elongations and greater hardness. The martensitic steels remain martensitic, but are harder after quenching than before. Steels of gamma iron are softened by quenching.

SERIES I.

Composition.			Max. Stress Kilos. sq. m/m.	Elastic Limit Kilos. sq. m/m.	Elongation per cent.	Shock Frémont.	Hardness Brinell.	Constitution.
Carbon.	Nickel.	Manganese.						
0·128	1·4	5·7	141·4	99·0	6	9	311	Martensite.
0·166	2·1	6·8	has always badly broken.			3	364	Martensite and γ iron.
0·159	2·0	15·7	70·2	29·3	7	40	187	γ iron.
0·098	12·2	5·3	107·4	41·2	15·5	25	212	Martensite and γ iron.
0·202	12·0	8·7	61·8	35·3	36·5	36	146	γ iron.
0·180	12·0	15·8	65·7	46·0	35·5	37	170	γ iron.
0·365	31·1	5·0	70·6	27·0	30	40	149	γ iron.
0·191	31·1	8·0	72·2	27·0	22	32	124	γ iron.

SERIES II.

Composition.			Max. Stress Kilos. sq. m/m.	Elastic Limit Kilos. sq. m/m.	Elongation per cent.	Shock Frémont.	Hardness Brinell.	Constitution.
Carbon.	Nickel.	Manganese.						
0·670	1·76	4·7	has always badly broken.			3	277	—
0·815	2·32	7·0	73·8	43·6	3	7	235	γ iron on the limit.
0·729	2·00	14·4	80·3	49·6	18	33	212	γ iron on the limit.
0·623	12·08	5·5	100·8	41·6	11·5	40	174	γ iron on the limit.
0·752	28·60	5·2	93·2	25·5	32	40	174	γ iron.
0·728	31·00	7·9	86·9	27·0	30	28	196	γ iron.

SERIES III.

Composition.			Max. Stress Kilos. sq. m/m.	Elastic Limit Kilos. sq. m/m.	Elongation per cent.	Shock Frémont.	Hardness Brinell.	Constitution.
Carbon.	Nickel.	Manganese.						
0·092	4·96	0·525	115·3	92·2	7	7	217	Martensite.
0·172	6·88	1·425	148·1	79·3	6	10	387	Martensite.
0·434	3·32	1·350		badly broken.		5	402	α iron + martensite.
0·401	4·96	0·975		badly broken.		4	375	α iron + martensite.
0·605	4·10	0·600	119·9	?	6·5	3	217	Martensite on the limit.
0·295	5·10	11·800	106·6	50·4	30	42	137	γ iron and a little martensite.
0·260	7·20	5·100	70·5	70·5	2	5	207	Martensite + γ iron.
0·435	5·40	7·800	86·8	47·1	47·9	7	114	Martensite + γ iron.
0·813	4·00	3·300	57·0	15·9	5	0	187	Martensite + γ iron.

Abstracts from the Foreign Press.

New Hydro-Electric Installation at Clermont Ferrand.—The Compagnie du Gaz de Clermont Ferrand, having to increase its electric lighting plant, decided on using water power, which was obtained by building a dam across the river Sioule up in the hills near Queuille, so as to form a lake about 4½ miles long by 160 yards wide. The following details of the plant are taken from an article on the subject that appeared in No. 11 of *La Houille Blanche*. The generating station is erected at the base of the dam and contains six Francis turbines, working under a head of 70-80 ft. and developing 1,200 h.-p. each at a speed of 333 revolutions per minute, the efficiency under full load being 76 per cent. and under three-quarter load 80 per cent. Each turbine is coupled direct to a 1,000-kw. three-phase dynamo, with Westinghouse multipolar excitation machines (50-kw.), and develops a tension of 1,000 volts. This tension is transformed into 20,000 volts by four groups of three single-phase 375-kw. transformers immersed in oil, and the high-tension current is conveyed to Clermont, a distance of 18¾ miles, through a duplicate line of overhead wires mounted on lattice iron poles, 304 in number, at an average distance of 323 ft. apart. Where the line crosses the railway it is protected by a network of steel wires, 20 ins. apart, stayed by L-irons to impart rigidity. Elaborate means are adopted at the generating and transforming stations to nullify the influence of static discharges, by means of self-induction coils and Wurts dischargers.

At the Clermont sub-station, each group of three transformers is mounted in a reinforced concrete cell, and transforms the 20,000 volts current down to 3,000 volts, and the collectors and high-tension cut-outs are in similar cells in the basement. The installation was constructed by the Westinghouse Co., and a 450 h.-p. Willans-Robinson compound engine, driving a 315-kw. ampere Westinghouse alternator, is provided at the sub-station, as a reserve in case of breakdown.

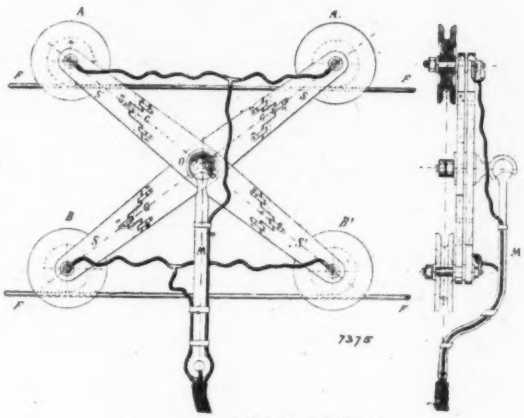
Projected Underground Tramways in Berlin.—The Berlin Tramways Company has elaborated a project of shallow underground tramways, says the *Zeitschrift für Elektrotechnik*, to relieve the pressure of traffic in the busiest streets, including the Leipzigerstrasse, Potsdamerstrasse and Unter den Linden. For example, trams coming from the south-western suburbs will descend an incline at the Potsdamer Brücke, into a four-track tunnel extending as far as the Charlottenburgerstrasse, at which point one pair of tracks is diverted northwards into a branch tunnel, coming to the surface at the Gensdarmenmarkt, whilst the second pair of tracks continues underground eastward to the Ross-strasse. In the Charlottenburg line the tunnel commences outside the Brandenburger Thor and extends all along Unter den Linden (replacing the existing surface lines there) and coming to the surface on either side of the Opera House. At present the traffic through the Potsdamerplatz is very congested, the square being traversed by about 5,300 cars daily, and as the change from trolley to conduit system is effected here, blocks are frequent. The four-track tunnel line is intended also to compete with the new underground railway branching from the existing overhead line at the Potsdamerplatz. The project, which is under consideration by the municipal authorities, is estimated to cost sixty million marks, and in consideration of this expenditure the company is endeavouring to secure an extension of its concession, which otherwise expires in 1949.

Resistance of Lead-Antimony Alloys for Accumulator Grids. — The relative electrical resistance of pressed lead and pressed antimony being approximately 1·2, Rosset endeavoured to utilise this as a basis for determining the composition of lead-antimony alloys for accumulator grids, but finds that the relative maximum resistance is reached with alloys containing 10 per cent. of antimony. Nevertheless, the results of his experiments, which are set forth in the *Centralblatt für Accumulatoren-Technik No.* 22, show that the purity of the 10 per cent. alloy is greater in proportion as it approximates to the requisite density and as the hardness and resistance are high and normal, the appearance of abnormal values for any one of these factors indicating the presence of extraneous impurities or dissolved oxide.

Grisson Gear for Electric Haulage in Collieries.*—The main haulage road at the Konsolidation Pit, Gelsenkirchen, which is about 1,800 yds. long and has two very sharp curves (90–100 deg.), is operated by an electromotor the speed of which is reduced by means of a "Grisson" gear. The 30-h.-p. polyphase motor, running at 475 revolutions per minute, is coupled direct on to the first cam wheel of the "Grisson" gear (No. 608), which reduces the speed to one-eighth, and this in turn is coupled to the second gear (No. 1,010), which brings it down to 1 in 10 for the rope pulley shaft. The motor and gear are mounted on a solid frame and take up a minimum amount of room, and the gears run in oil in dustproof casing. The rope pulley has three grooves, two of them being wood-lined to take a better grip of the rope, while the counter pulley consists of three loose grooved wrought iron rings. The oncoming rope passes over a 20-in. guide roller in front of the driving gear, then over a 62-in. pulley in

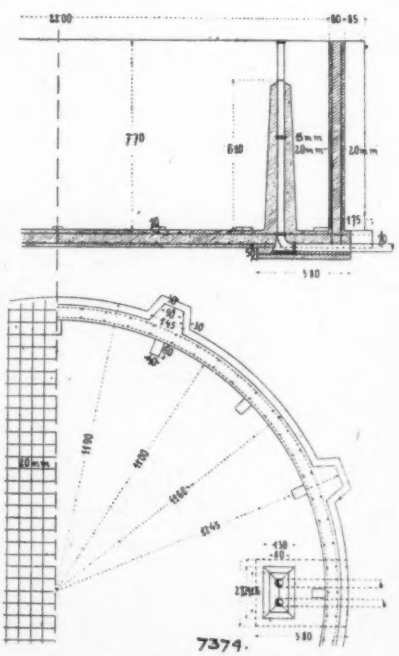
* *Elektrische Bahnen und Betriebe*, No. 33.

rear of same, and back to the first groove of the 64-in. driving pulley, afterwards slinging round the loose counter pulleys and other grooves of the driving pulley in succession, and being then returned into the haulage road as tail rope over a 36-in. pulley. In the road the rope is carried over rollers at short intervals to prevent dragging against the rail sleepers. The tub forks engage with hemp knots on the wire rope, metal knots having been discarded owing to risk of breakage. In curves the guide rollers are mounted close together and are star-shaped to leave room for the forks to pass between them. In addition to occupying a small amount of space, the "Grisson" gear has the advantage of working quietly and without noise, the wear and tear of the working parts being also insignificant.



ELECTRIC TROLLEY.

Electric Trolley for Double Conducting Wires.—A new electric trolley has been designed by Sig. Pomella for use with a double conducting wire, and especially for traction without rails. The following details of the apparatus are extracted from the *Rivista Tecnica*, No. 21. The trolley has four grooved rollers, *A A* and *B B*, running respectively on the upper and lower wires *F*, *F'*, which are suspended in the same vertical plane. The rollers are mounted on shafts at the extremities of an X-frame, *S S'*, the arms of which pivot at the point of intersection, *O*. The extended axis of the pivot forms a ball joint, from which depends a curved vertical arm, *M*, attached to the flexible connection through which the two wires convey current to the motor of the vehicle. The trolley is suspended from the conductors by first laying the rollers *B B'* on the lower wire, and then extending the X-frame until the upper rollers engage with the upper wire. The weight of the frame and rollers is sufficient to secure proper adhesion, and this is increased by the pull of the vehicle when running. By means of the ball joint, the vehicle is enabled to follow the sinuosities of the traffic without risk of detaching the trolley from the wires, even when the angle of pull exceeds 45 deg. At the same time it is not essential that the two conducting wires should be absolutely in the same vertical plane or at a strictly uniform distance apart throughout, the ball joint on the one hand and the pivoted X frame on the other enabling irregularities in these two respects to be overcome without difficulty.



FERRO-CONCRETE GASHOLDER PIT.

Ferro-Concrete Gasholder Pit.—In enlarging the municipal gasworks at Wernigerode it was decided to construct the gasholder pit of ferro-concrete, in accordance with the plans furnished by Mölders & Co., of Hildesheim, the particulars of which are set forth in No. 11 of *Beton und Eisen*. Owing to the irregular nature of the subsoil the foundation was built on a double grating of ferro-concrete 27 in. thick, consisting of $\frac{7}{8}$ in. round iron rods, set

2 in. apart both ways. The irons for the walls were of the above thickness, this being strong enough to absorb all the tension strains, the concrete serving merely to retain the water. The upright dividing irons ($\frac{3}{8}$ in. in diameter) were set 40 in. apart, whilst the horizontal irons were arranged as an outer and inner ring, embedded in a wall of concrete $23\frac{1}{2}$ in. thick. The concrete foundation was composed 1 volume of Portland cement to 5 of sand and 7 of granite fragments, that for the walls being in the proportion 1:4:6. The superiority of ferro-concrete, over rammed concrete is particularly apparent for this class of work, owing to the tangential and radial strains set up in the walls by the pressure of the water, which strains ordinary concrete is unsuitable for supporting, even when of considerable thickness. The internal diameter of the pit is 72 ft. and the height of the wall 25 ft. 3 in. The quantity of concrete consumed was 11,550 cubic ft. and the weight of iron 23 tons 7 cwt., the total cost of materials being £458. This works out cheaper than concrete alone, the quantity required in such case being over 28,000 cubic ft. and the cost £500.

The Bréviaire Anti-Reversal Crank for Explosion Motors.—It not frequently happens, in starting explosion motors, that when the pistons have not been set in the right position for starting, the explosion causes a sudden reversal of the crank and a more or less severe accident. To prevent this, the Bréviaire crank* is composed of three parts, the crank proper *E* with its pawl *D*, a fixed cam disc *C*, and a loose wheel *B*, the crank being also mounted loose on the shaft. The pawl *D* engages on the one side with the cam disc *C*, and on the other with the teeth on the wheel *B*, the pawl itself being toothed for this purpose. The wheel *B* can only turn in the forward direction, and is attached by the hub to the part of the frame supporting the crank shaft *F*. When the crank is being set for starting the motor, the slight friction of the wheel *B* causes the point of the pawl *D* to engage in one of the (four) recesses of the cam disc *C*, whereupon the crank and shaft turn together. Should the explosion occur before the piston is in the right position past the dead point, the crank is driven back, but as the wheel *B* cannot turn in this direction, the movement causes the teeth on the pawl to engage with those on *B* in such a manner as to draw the point of the pawl out of contact with the cam disc and free the crank from the shaft *F;* and even if the motor continues to turn backward, there is no risk of the pawl engaging with the cam.

Protecting Ferro-Concrete Structures from Lightning.—In the opinion of Van Gulik the greatest amount of damage to ferro-concrete structures by lightning would be at the ground level, at the points where the current discharges through the concrete to earth, thus entailing the collapse of the structure in the event of a number of the columns being affected. For this reason he recommends* that a number of the columns should be provided with round iron rods with an earth connection. To secure protection it is also advisable to connect the irons in the columns with those in the roof and beams by means of wires, while the structure is being put up. At the same time a horizontal iron rod should be connected with two of the irons in a column, so as to project through the surface at a height of about 3 ft. above the ground level. This will enable a good earth connection to be made. Furthermore, the irons in the concrete should, in various places, be connected with metal wires projecting through the concrete, in order to make contact with iron machinery, &c., and stay irons within the building.

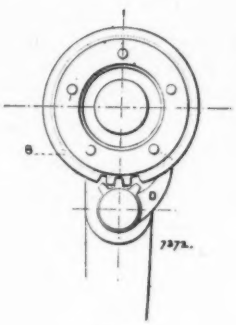


FIG. 1

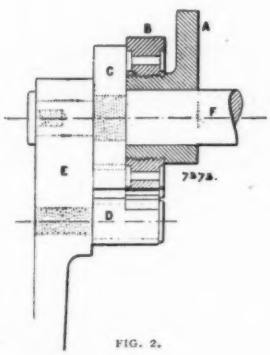


FIG. 2.

New Swedish Locomotive.—The new four-coupled express engines of the Bergslagernas railway, a description of which is given

* *La Locomotion Automobile*, No. 16.

* *Beton und Eisen*, No. 11, p. 269.

in a recent issue of *Die Lokomotive*, are fitted with Schmidt superheaters, part of the upper tubes in the boiler being replaced by tubes about 5½ in. in diameter, in which are inserted 1¾ in. U-shaped superheater tubes. Two of these U-tubes are mounted in each of the wide tubes, and the ends of the U-tubes debouch into two separate chambers in the smoke-box, the one chamber communicating with the boiler, through the regulator, whilst the other leads to the valve chests of the cylinders. By this means the steam can be heated to 300° C. and over, according to the heating surface, which in these engines is 183 sq. ft., the total heating surface of the boiler being 965 sq. ft. The grate surface is 17½ sq. ft., the ratio to the total heating surface being 1:54·5. The fire-box is very deep and extends between the frames. The engine has the following principal dimensions. Diameter of cylinders 18½ in., stroke 24 in., diameter of driving wheels 5 ft. 7½ in., fixed wheel base 7 ft. 10 in., total wheel base 21 ft. 4 in., steam pressure 10 atmospheres, weight of engine in working trim 46 tons, weight of tender loaded 22 tons, coal 3 tons, water 8¾ tons.

New Electric Railway Project for Hamburg.—A new project has been drawn up by the Senate of Hamburg for the construction of an outer circle electric railway through the city and suburbs. According to the *Elektrische Bahnen und Betriebe*, it provides for a double track of standard gauge, partly overhead and partly underground. Starting from the Hafentor on the river front, the line will dip into a tunnel on reaching the Rödingsmarkt, which tunnel will extend past the Bourse, under a new main street to be cut between the Rathaus and the central railway station, and then eastward till it comes to the surface at the Berlinertor. The surface line proceeds northward through St. Georg to Barmbeck, and westward thence to Winterhude, to then turn southward as far as Schlump, from which point a tunnel leads to the Hafentor, thus completing the circle. There will be a branch tunnel from Schlump to the market-place at Eimsbüttel, a surface line from Winterhude northward to Ohlsdorf, and another from St. Georg south-eastward to Rotenburgsort. From this latter terminus it is contemplated opening up connection later with the circle at Barmbeck. As far as possible, the line will be constructed on embankments and in open cuttings, but financial, æsthetic, or other important factors may necessitate the use of tunnels and viaducts. The municipality will build the line, a contract having been made with Messrs. Siemens and Halske and the Allgemeine Elektrizitäts-Gesellschaft to do the work for forty-one million marks, but the working will be leased to a company on a profit-sharing agreement. The cost of the land to be acquired is estimated at about seven million marks, and supplementary works to be done by the municipality are expected to cost nearly five-and-a-half million marks.

Electrical Notes.

BY ANDREW STEWART, A.M.I.E.E.

Electric Power in the Factory.—The paper by Col. Holden to the Institution of Electrical Engineers on Electric Power in the Royal Gun Factory, Woolwich Arsenal, proved of unusual interest because it introduced the engineering profession to several devices which, although not actually novel, were hitherto comparatively unknown, and scarcely, if ever, used in such installations.

Electric power had been used prior to 1900, but it was in that year that the first two large tools were electrically driven, viz., two boring machines with 25 h.-p. variable speed motors, having the speed control by varying the shunt current only, thus obtaining a variation of 3½ to 1. The motors are arranged with their shafts at right angles to the machine shaft, and the drive is by a worm and wheel, the worm being coupled to the motor shaft through a flexible coupling, and its thrust taken by a thrust bearing of the marine type. The author considered a worm drive best for the work in question, as the drive is much more even; indeed, he stated that for fine boring a hole of 12 in. to 20 in. diameter, 50 ft. long, without a variation greater than ·004 in. in the diameter, no other gear was practicable. In addition to the main drive there is a 15 h.-p. series motor at the other end of the bed, which is 150 ft. long, for the purpose of rapidly moving the boring head and saddle.

In the more recent conversions to electric driving, the series motor operating on the boring head and saddle have been eliminated, and a shunt motor not only feeds the boring bar, but moves saddle as well. Fig. 1 shows how this is done. The motor drives the gear through the flexible coupling *H*; the shaft carries a pinion with the clutch *G*, both of which are mounted on a sleeve; beyond this a magnetic clutch *B* is fixed and the worm gear *C*. The latter drives the change gear *D*, which is similar to that of a screw cutting lathe, which in turn drives the worm-wheel *E* through a worm, which it will be noticed can be clutched mechanically by the claw clutch *A*, operated by a hand wheel, to the screw shaft *I* moving the saddle. The lever *F*, seen close by the hand-wheel, moves so that it interrupts the circuit to the magnetic clutch *B* the moment the clutch *A* is "in." It is apparent, therefore, that the normal slow motion, through the double worm and change gear, cannot be used till the fast movement through the spur gear is disconnected, the latter only being employed to shift the boring head quickly.

It will be seen that a wide speed variation can be obtained, as not only is the motor capable of considerable range of speed by shunt control and therefore with economy, but the change gear adds still further to the range.

The magnetic clutch referred to is largely employed throughout the works, there being about 117 in use, and the fact that they may be operated by simply turning a small switch makes them of considerable value where the clutch is in an inaccessible position. The general design of the clutch will be clear from Fig. 2, where the clutch is seen mounted on a shaft with a cone pulley. The magnet consists of a circular disc of wrought iron or steel having an annular groove cut in it. Into this groove the exciting coil is placed, consisting of, in this case, No. 36 copper wire. As the magnet rotates, provision must be made for carrying the current to the winding, and this is effected by two grooved rings into which carbon contacts are pressed by springs. When the magnet is excited it attracts and holds the iron disc screwed to the side of the larger cone pulley, and is thus carried round by the pulleys, if these are driven. In order to prevent the magnet and the iron disc from sticking together, due to residual magnetism, a thin steel disc is placed between them. This, owing to its lower permeability, effectively prevents any residual magnetism.

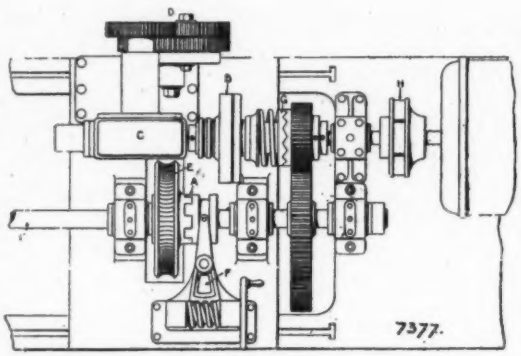


FIG. 1.

Such clutches will transmit quite a lot of power. Two sizes only are used at the Royal Gun Factory, one capable of transmitting 6 h.-p. and another 25 h.-p., at 300 revolutions per minute, the exciting current representing 1 to 1½ watts per h.-p. transmitted (about $\frac{1}{700}$ of a h.-p. per h.-p. transmitted), though it is possible to improve on this.

It is evident that Col. Holden's preference for planing machines which cut in both directions with two separate tools is to a large extent justifiable, on the score of saving of power, labour, and time, for no matter how rapid the return stroke may be, some time will be lost, and his method of effecting the control is undoubtedly interesting. The planer is driven by a variable-speed shunt-wound motor which runs continuously in one direction, and drives, by means of a bevel-pinion, two bevel-wheels revolving in opposite directions. These two bevel-wheels run loose on the screw shaft of the planer, but may be fixed to it by means of magnetic clutches. When the bed gets to the end of the stroke, it opens one switch and closes another, which releases one bevel-wheel and clutches the other to the shaft by means of the magnetic clutches. Reversal takes place quickly and silently, and the only evidence of change is a 25 per cent. rise in the motor current at the moment of reversal. This arrangement not only eliminates belting, but the expensive switch-gear which would be necessary if the motor was reversed. It will be noted that the arrangement is particularly adapted to planers with a screw drive to the table instead of a rack and pinion, which latter Col. Holden viewed with disfavour.

The use of magnets for carrying iron and steel is not so common in this country as it is in the United States of America, where several steel companies employ them for handling large masses of iron or steel. The difficulties in the way of slinging shot are sufficiently obvious, and it is many years since Col. Holden designed the lifting magnets which are now used in Woolwich Arsenal for handling projectiles weighing often as much as 1,800 lbs. These magnets weigh rather less than 56 lbs., and require only about 120 watts (0·16 h.-p.) for excitation. For handling ship plates, rails, or, indeed, almost all products of iron and steel works, such magnets are valuable, as, apart from all other considerations, the saving in labour slinging the metal is considerable. The Illinois Steel Co. have for years used such magnets for handling steel blooms at a low red heat, and although the author of the paper in question did not refer to the numerous uses of such magnets, he is no doubt alive to their possibilities.

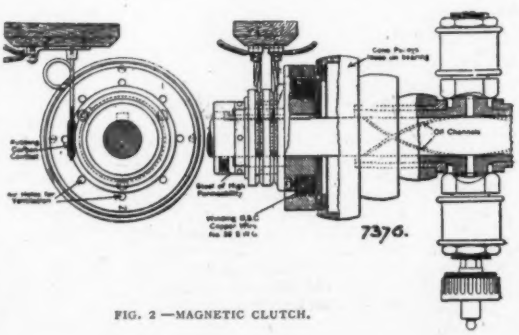


FIG. 2.—MAGNETIC CLUTCH.

The First Electrically-driven British Cotton Mill.—Another important development in the application of electric power to industrial purposes is the completion of the first electrically-driven cotton mill in England, viz., the Acme Spinning Mill at Pendlebury, where some 1,200 h.-p. of electric motors have been installed throughout the mill, to the entire exclusion of steam plant of any kind, power being supplied by the Lancashire Electric Power Co.

Many unjustifiable aspersions have been cast on the business acumen of those responsible for the management of English cotton mills, and their engineering advisers have often had a fair share of the blame for apparent want of progress in this direction. The equipment of several mills in Spain and Italy by British electrical engineers has been cited to show that electrical engineers, at any rate, were fully capable of carrying out such work, and therefore the cause of the slow progress of electric-driving in the textile industry has been laid to the conservatism of the leaders of that industry. This, however, is not justifiable, as economic considerations led to the introduction of electric driving in textile factories over ten years ago, chiefly in the southern States of North America, and on the continent of Europe. Fuel was, in many of these places, 30*s.* to 45*s.* per ton, and the burden of these charges led mill owners to seek out and develop such waterfalls as were available. The capital cost of developing these sources of power proved expensive, and the annual cost of 1 h.-p. delivered to the mill varies from £3 10*s.* to £10. The economic margin between that and steam power, at anything from £5 to £14 per h.-p. year, was sufficient to give a considerable impetus to the introduction of electric power in these districts.

Such economic considerations are absent in Lancashire and Yorkshire, for in these counties a h.-p. year, generated by a triple-expansion engine of the economical type found in these mills, does not generally reach the lowest figure already mentioned, hence the conversion of that power into electrical energy and back again into mechanical power at the point to be utilised did not seem likely to improve matters, especially if the interest on the capital cost of the electrical equipment were taken into consideration. With the advent of power distribution companies, the prospect of being able to purchase power from an outside source, and so save the capital cost of boilers, engines, buildings, &c., seemed to hold out reasonable prospects of financial advantage, and we therefore have the Acme Spinning Mill as the first complete electrically-driven cotton mill. This mill, which has 75,000 spindles, has cost approximately £100,000, and it is estimated that £10,000 was saved by the elimination of the power generating plant, rope tower, and by the lighter construction of the building due to the heavy shafting being eliminated. To lighten the shafting as far as possible speeds of 560—580 revolutions per minute have been adopted, and many of the motors are small, though the spinning frames themselves have in most cases been grouped to a line shaft and driven by motors of 75 to 200 h.-p., a practice which is more or less in line with the mills in South Carolina, where excessive sub-division of the motors has been found to be expensive by reason of the lower efficiency and higher first cost of small machines.

It does not seem likely that any substantial reduction in the cost of power will be possible in the case of the mill in question, but the elimination of power generating plant from the premises will enable the owners to concentrate their efforts on the principal part of their business, while the indirect results of electric-driving, such as higher quality and somewhat greater output, owing to the more uniform turning effort and steady speed of the power plant, should prove such as will justify the innovation. Much, however, depends on the charges of the power distribution company, for power is generated at a cotton mill on fairly economical lines, and although the power supply company scores by reason of the magnitude of its operations and the diversity of the demand, still it has to pay interest on the capital sunk in the transmission line and sub-station, the losses therein, and also make a profit. It remains to be seen, therefore, if there is sufficient difference in the operating cost of a 1,200 h.-p. plant on the spot and a 20,000 h.-p. plant some distance away, to justify the innovation. As the owners of the Acme mill have a steam-driven mill of almost the same size adjoining the electrically operated mill they possess advantages for direct comparison which are not often available.

Electric Traction on Main Line Railways.—The problem of how to deal economically with a mixed traffic on a main railway serving a sparsely populated district, is not one that has hitherto received serious consideration at the hands of railway or electrical engineers. A rapid suburban service is, as is well known, more economically handled by electric traction than by any other means; indeed, such lines may be said to be the logical outcome of an electric tramway, or light railway, where frequent stops and rapid acceleration are the normal operating conditions. When dealing with trunk lines conditions differ; stations are much further apart, the traffic fluctuates enormously, for there may be only one or two trains per hour requiring anything up to 1,500 h.-p.; and stops are infrequent, rendering less important the question of acceleration, which exercises a predominant influence on the passenger-carrying capacity of a busy suburban line with numerous stations. Moreover, railway companies handling both suburban and heavy trunk line traffic have for some time realised that the direct current system with its numerous sub-stations, all of which have rotating machinery, and, consequently, expensive equipment and staff, could hardly be

a satisfactory solution of the railway electrification problem, as these sub-stations, instead of being constantly loaded, would only have a reasonable load at infrequent intervals, and as a reduction of the number of sub-stations would mean an increase in the number and size of direct current feeders, which, if they are to transmit loads of the magnitude already indicated, must be of large area owing to the limited pressure at which the trains can be fed. The large capital investment which is necessary in any case, and the heavy annual charges, are such as would cause most railway engineers to pause ere committing themselves to a scheme of this kind. The obvious solution of the problem is to so raise the pressure at which the trains can be fed that the section of the feeders is reduced to a mere fraction of what is necessary with direct current at 600—650 volts, while the elimination of rotating apparatus from the sub-stations is essential if the labour item along the line is to be kept within reasonable limits. The two possible systems are the polyphase, as used on the Valtellina Railway* and several of the Swiss and Italian mountain railways, and the single-phase system which has just been adopted (1) by the New York—New Haven and Hartford Railways, for handling the traffic from New York to about twelve miles out, where the long-distance traffic is then taken over by steam locomotives, and (2) which has been practically decided upon by the London, Brighton and South Coast Railway for a part of their South London line.

Reference has already been made in our November issue to the performance of several single-phase lines, though these are generally short lengths handling single cars or trains of two cars, and, while demonstrating the reliability of the equipment, do not provide much data for the railway engineer, who naturally wishes to see an equipment on a scale comparable with that on his own lines.

The experiments now being carried out by the Swedish Royal Railroad Administration will to some extent provide that data, and these experiments will no doubt be closely watched. In a paper to the Congress of Swedish Engineers, Mr. Robert Dahlander, the chief electrical engineer to the Administration, describes the plant, and some of the considerations which led to the adoption of the single-phase system. Direct current was ruled out of consideration, probably for the reasons already indicated, and the choice lay between three-phase and single-phase. The former had the advantage of simpler construction, lower weight, and absence of a commutator. The necessity of two trolley wires for three-phase instead of one, as with single-phase, was an argument in favour of the latter, though we cannot agree with Mr. Dahlander that the single-phase system has the additional advantage of higher possible line pressure without trouble, and the limit in this direction is 3,000 volts for three-phase. It must not be forgotten that at the Berlin-Zossen high-speed trials, where three-phase was employed, trolley wire voltages of 14,000 volts were used, collecting higher powers at much higher speeds than is likely to be used on standard gauge lines for some time to come, and that no trouble was experienced on this part of the work.

The importance of high trolley voltages is apparent when due consideration is given to the importance of keeping the number of sub-stations as small as possible; for, although these alternating current sub-stations do not involve the installation of rotating apparatus, they necessitate a small amount of attention, and a fair capital expenditure for buildings, static transformers, switch-gear, &c. The number of such buildings on a stretch of London and North-Western, Midland, or Great Northern Co.'s main line would, even at intervals of forty or fifty miles, swallow up a considerable amount of capital, and when one takes into consideration the fact that the capital cost of such a revolutionary change on our trunk lines will be the most serious barrier, long after the engineering problems have been practically settled, the importance of keeping the line equipment, as far as possible, down to the feeders and trolley wire will be apparent. As the trolley wire pressure and average load on any given section, determines the number of sub-stations, it will be seen that as the average load cannot be varied to suit the convenience of those responsible for the engineering side of the equipment, the question filters itself down to a question of trolley wire pressure, and it appears that in the experiments already alluded to, provision is made for trolley wire voltages of 3,000, 5,000, 6,000, 10,000, 12,000, 15,000, 18,000, and 20,000 volts. In our next issue we hope to give illustrations of some parts of the equipment of the 6¾ miles of line on which the experiments are being carried out, as well as further data on the subject generally.

* The new electric locomotives for this line were described in our October and December issues.

Book Reviews.

The Elements of Railway Economics. By W. M. ACWORTH, M.A., Barrister-at-law, author of "The Railways of England," "The Railways and the Trader," &c. 1905. (Oxford: at the Clarendon Press.) Price, 2s. net.

Mr. Acworth tells us in his preface to this little volume that in his capacity as lecturer on Railway Economics at the London School of Economics, he had been constantly hampered by the want of an English text book on the subject, and that he finally determined to undertake himself the duty of writing such a work. The present volume is not the complete work but only an instalment, and the author is apologetic for having ventured to publish what he calls "an incomplete fragment;" but there is no need for him to adopt this attitude, for the volume in itself deals in a very skilful manner with a large variety of railway questions, and the public owes the author a debt of gratitude for having placed at its disposal in so readable a form so much instruction on a very important and very complex subject. The publication of the volume in its present form is to our mind an advantage, for a complete treatise would necessarily become more technical as it advances, and though it would be welcomed by serious students of economics, it would not be attractive to the general public. But this little work must appeal to all. The student of economics will study it closely, and will wait eagerly for the continuation, and at the same time many who are not economists may be induced to read it because of the magic word "elements" in the title. We hope the number of this latter class may be very large, as the subject deserves more careful attention from the public than it is wont to receive.

Probably there are few undertakings more subject to criticism by the "man in the street" than railways, and one hears continually of the iniquities of railway companies, of the unfair rates imposed, and generally of the pure unadulterated wickedness of the directors. It would be foolish to characterise all such criticisms as unfounded, for there are many *apparent* injustices and contradictions in railway rates, and it is purely by appearances that the man in the street goes on forming his opinions; but if he can be induced to read what Mr. Acworth has written in these pages, he will find that this is a case in which appearances are deceptive, and that the principles underlying railway methods of charging are in fact almost identical with those he applies in his own business, whatever that may be. Mr. Acworth explains very concisely and very clearly what is the exact nature of a railway and of the business it carries on, and considerations of vital importance which would not be realised by merely external and cursory examination are soon brought home to the mind of the intelligent reader. Some popular ideas regarding railways and railway management are discussed and shown to be fallacious, and the author discusses in a very interesting manner each of the distinguishing features of such undertakings. The earlier chapters are devoted to the consideration of capital expenditure and expenditure on maintenance of the undertaking, and thereafter the author passes to consideration of railway income, showing the historical development of the principle on which rates are actually fixed. Two chapters are devoted to an exposition of the real meaning of the technical phrase "charging what the traffic will bear"—a phrase which is, in its terms, open to misinterpretation, and gives rise to much misunderstanding—and the concluding chapters deal with the methods and machinery by which the principle underlying that phrase is put into operation. These final chapters contain some very forcible criticisms on recent Parliamentary legislation regarding railways.

We earnestly hope that this volume may be widely read, and we strongly recommend it to our readers, however little be their interest in the science of economics. To the author we offer our congratulations on the success which he has achieved in making a very difficult and complex subject at once attractive to, and comprehensible by, every intelligent reader.

Molecular Forces and Newtonian Laws. By ALEXANDER CLARK, M.A. 1905. (Glasgow: W. and R. Holmes.) Price, 3s. 6d. net.

As the preface to this volume informs us that the author's views of the molecular forces have been obtained by deduction from the Newtonian Laws, and that he believes that by this means he has established beyond reasonable doubt the general principles of magnetism, electricity, and chemical affinity, while a publisher's notice announces that "the views set forth in this work are strictly scientific, and should supersede the common theories at present taught on the subject," we naturally prepare ourselves at the outset for a feast of good things. Alas! before we have gone far, we find that it is but the old, old story of a person venturing to propound new theories on a scientific subject which he has very imperfectly understood. Under any circumstances this is regrettable, but in the present case it is especially so, as Mr. Clark has evidently spent much labour on his work and shows in many ways that he has sufficient training in mathematics and science to enable him to understand his subject properly if only he were to turn his energy into the proper channel.

Described briefly, the work is an attempt to deduce from the Newtonian Laws, and especially from the law of attraction or gravitation, all the laws of electricity, magnetism, and chemical affinity. What he in fact does, however—though he may not be aware of it—is to

explain the law of gravitation by a theory made to fit in with his theory of magnetism, while the other subjects are also explained by further modifications of this same magnetic theory. Take, for example, the following passage from the sections in which he begins to account for the law of attraction :—

"The property of matter underlying attraction is *polarity*. Every atom and every molecule appears to have a *positive* and a *negative* pole by means of which they are attracted towards each other. . . . It may be convenient to speak of these atomic or molecular poles as *magnetic points*."

In the ordinary phraseology of magnetism, however, "like poles repel one another," and as there is no evidence of repulsion in ordinary gravitation, the author has to get over this difficulty by explaining away repulsion altogether in all the sciences with which he deals. This he does by the astonishing announcement that "between similar magnetic points there is no force," failing to notice that in another part of the volume he has himself shown (p. 64) that between similar poles there is in fact a force—whether it be called "repulsion" or not—which tends to drive these two poles apart. From his theory of magnetism, Mr. Clark can deduce to his own satisfaction, as a special case, the law of gravitation, but not *vice versa*, and he has to treat magnetism as something different. "Gravitation," he says (p. 51) "always acts in straight lines, but this is not the case with magnetic force."

As to his theory of magnetism itself, there is nothing in it, so far as it is unobjectionable, which is original, and on this point we have a word to say. On pp. 44-45 he describes and holds up to ridicule "the celebrated theory of Ampère," which, according to the author, "belongs entirely to the sphere of imagination—the wonder is that it should ever have obtained a place in science;" but when he discloses his own theory, it is almost exactly that of Weber, yet the name of Weber is nowhere mentioned in the text. Why is this? If the author knew of Weber's theory, he ought not to have propounded his own theory as something quite original, and certainly should have mentioned the name of that physicist; if he has never heard of that well-known theory, we need no further evidence of his imperfect study of the subject.

Enough has been said to show that we cannot recommend this book to earnest students of science. We might go on through each chapter and point out glaring faults and errors, but we will content ourselves with one or two quotations, which will show our readers what to expect.

"This affords a conclusive reply to the theory, adopted by some eminent authorities, that electricity and light are identical. . . . This theory ignores the distinction between potential and kinetic energy, and is therefore at variance with the conservation of energy" (p. 72).

Electric currents, it may be here said, are explained by the author by the motion of the material particles of the body in which the current flows. How, then, are we to explain non-conductors? Here is the author's plan :—

"If the lines of force lie through a non-conductor, discharge cannot take place, because the substance does not possess molecular mobility, and resists motion" (p. 75).

Yet, a few pages further on, we find it stated that "the nearest approximation" to a perfect insulator is dry air, while that to a perfect conductor is pure silver. This is correct, but which substance has the greater "molecular mobility"?

"If the common theory were correct, that an electric current proceeds from higher to lower potential, more work, or heat, would be available at one part of the circuit than another. But this is not the case."

Ergo, this is one of the "common theories" which are now to be superseded!

Finally, at p. 222 :—

"This theory [of Sir Oliver Lodge] resolves magnetism into a mode of motion. But *motion, as we have seen, is repulsive*, and magnetism is admittedly a force of attraction." For the italics here, we are responsible.

May we, in conclusion, point out to the author that he will learn much if he will turn his attention to a study of what goes on *in the ether* when dealing with electrical and magnetic phenomena, instead of looking only to the tangible material bodies? At p. 66 he gives us "the reason" for repulsion between two magnets at a distance apart, that "the atmosphere . . . is magnetised." But the same thing would occur in an atmosphere containing no magnetic gas, such as oxygen is. We hope Mr. Clark will try to understand the modern theories, including stresses in the ether, properly, and that he will pay attention to the "electrical atom" of Professor J. J. Thomson. Did we not believe that he has the ability, if willing, to understand all this work, we should not have devoted so much space to this review.

Graphic Methods of Engine Design.

By A. H. BARKER, B.A., B.Sc. (The Technical Publishing Co., Manchester.) 210 pp., 90 illustrations. Price, 3*s*. 6*d*. net.

This little book is written professedly for those whose knowledge of science and engines is limited, but who aim at becoming practical draughtsmen. Having this aim in view, we are surprised that the author did not give some of his explanations at somewhat greater length.

As might be expected from the title the author adopts graphic methods of solving problems wherever possible—advanced mathematics is entirely avoided. The book does not treat of the thermodynamics of the steam engine, nor of such considerations as valve leakage and cylinder condensation. The author has confined himself to what might be called the mechanics of the steam engine. A large part

of the book is taken up by a consideration of the problem of balancing, and the stresses produced in an engine frame by the lack of balance. There is a chapter on valve calculations, one on the dimensions of details, two on compounding, and one on fly-wheels. The book is clearly written and well got up. It should prove of assistance to those for whom it is primarily intended—practical draughtsmen.

Electric Traction. By JOHN HALL RIDER, M.I.C.E., M.I.Mech.E., M.I.E.E., &c. (London: Whittaker & Co.) 453 pp., 194 illustrations. Price, 10*s.* 6*d.* net.

This excellent volume deals in an exhaustive manner with the various details of electric tramway construction.

Generating plant, distributing systems, rolling stock, permanent way, overhead, conduit, surface contact and accumulator systems are all discussed in a clear and attractive style by the Chief Electrical Engineer of the London County Council Tramways.

Chapters are also devoted to switch gear, motors, controllers, combined lighting and traction plants and electric railways. The latter section will doubtless be amplified in future editions.

The Board of Trade regulations on the subject are added in the shape of an appendix.

The book contains many useful diagrams and suggestions; no space has been wasted, as detailed descriptions of tramway stations and its contents generally are full of interest from cover to cover.

So many pseudo-technical books of doubtful value have been published during the last few years, that it is a real pleasure to notice this valuable and up-to-date work, which is a credit both to the author and to his publishers.

The book will be of no little service to all who are connected with, or interested in electric traction.

Modern Iron Foundry Practice. Part II. By G. R. BALE, Asso.M.Inst. C.E. (Manchester: The Technical Publishing Co.) Price, 3*s.* 6*d.* net.

The present volume forming Part II. of "Modern Iron Foundry Practice" is devoted to machine moulding, shrinkage and distortion, physical tests of cast-iron, methods of cleaning castings, and foundry accounting. It is essentially a compilation, and the author gives throughout distinct evidence of wide reading.

The first chapter, comprising ninety-two pages, treats of machine moulding and moulding machines, and here the author has relied far too much on inspired descriptions of the various machines noted. In fact the treatment of each machine is from the makers' rather than the users' point of view, hence to the ordinary reader the subject-matter lacks the essential foundry "grip."

Remaining chapters call for little comment, a good description of sand blast cleaning is given in the second one, whilst the fourth is decidedly the best in the book and lucidly discusses the testing of cast-iron.

Manual of Chemical Analysis as applied to the Assay of Fuels, Ores, Metals, Alloys, Salts and Other Mineral Products. By EUGÈNE PROST, D.Sc. Translated by J. C. SMITH, B.Sc. (London: MacLaren & Sons.) Price, 12*s.* 6*d.*

The sub-title indicates the scope of this work, which in character is practical and modern. It will chiefly appeal to the industrial chemist, in that it gives a selection of methods for the analysis of the chief mineral products. These methods are reliable, and the work is worthy of every commendation. A feature of special interest is found in the inclusion of a description of Mahler's bomb calorimeter, and clear directions for determining the calorific power of fuels by this apparatus.

The translator has been fortunate throughout, though in some respects his efforts are almost too literal. For instance, p. 207, "black pig iron," "highly silicated cast-iron," "glistening white iron" and "spotted cast-iron" are unfamiliar terms in British practice.

On p. 214, in describing the estimation of carbon by colour we read:—

"Add little by little 10 cc. nitric acid of density 1·2, heat on the water bath to dissolve brown flakes which may occupy one or two hours."

This statement as to the solution of 0·2 gram of steel taking one or two hours is singular. In works laboratories, samples are weighed, dissolved and compared in a period considerably under one hour.

The Locomotion Problem. By CHARLES BRIGHT, F.R.S.E., M.I.E.E., Author of "Submarine Telegraphs," &c. 1905. (London: P. S. King & Son.) Price, 1*s.* net.

This little paper-covered volume contains a reprint of lectures delivered by the author to the Uxbridge Literary Institute, and in part at the Toynbee Hall. The lectures would, no doubt, be of interest to the audiences to whom they were delivered, but they scarcely seem to us to be of sufficient importance to deserve publication now in permanent form. The first lecture deals mainly with questions and recommendations regarding motor-cars, but since it was delivered, the Motor Car Act has been passed and the situation has thereby been considerably altered. The second lecture deals with "Roads," and contains a plea for extensive road improvements to make them suitable for motor traffic, and for a readjustment of road authorities.

List of Publications the principal contents of which are regularly indexed.

American Engineer and Railroad Journal, 140, *Nassau Street, New York*	20 cts.
American Machinist, 218, *William Street, New York*	4d.
Annales de l'Association des Ingenieurs sortie de Gand, *Rue Longue du Marais, 15, Ghent*...	2 frs. 30 c.
Australian Mining Standard, 31, *Queen Street, Melbourne*	6d.
Automobile Club Journal, 119, *Piccadilly, W.*	6d.
Automotor Journal, 44, *St. Martin's Lane, W.C.*	2d.
The Autocar, *Coventry*	3d.
Beton und Eisen, *Kortorung, 14, Vienna I.* ...	2 marks
British Clayworker, 43, *Essex Street, W.C.* ...	6d.
Bulletin de la Société International des Electriciens, 12 & 14, *Rue de Stael, Paris* ...	2 fr. 50 c.
Canadian Engineer, 62, *Church Street, Toronto*	10 cts.
Cassier's Magazine, *New York*	1/-
Centralblatt für Accumulatoren, *Gross Lichterfelde-West, Bellevuestrasse, 40, Berlin* ...	3 mks. 50 pf. per qt.
Colliery Guardian, 30 & 31, *Furnival Street, Holborn, E.C.*	5d.
Compte Rendu des Travaux de la Société des Ingenieures Civils de France, 9, *Rue Blanche, Paris*	—
Der Mechaniker, 113, *Potsdamerstrasse, Berlin, W.* 35	40 pf.
Dingler's Polytechnic Journal, *Berlin*	{ 3 mos. 6 mrks.
L'Echo des Mines et de la Metallurgie, *Paris*...	45 fr. p.a.
L'Eclairage Electrique, 40, *Rue des Ecoles, Paris*	1 fr. 50 c.
Electrical Engineer, 139, *Salisbury Court, E.C.*	3d.
Electrical Review, 4, *Ludgate Hill, E.C.* ...	6d.
Electrical Review, N.Y., 41, *Park Row, New York, U.S.A.*	10 cts.
Electrical Times, 8, *Breams Buildings, Chancery Lane, E.C.*	2d.
Electrical World and Engineer, 120, *Liberty Street, New York*...	10 cts.
The Electrician, 1/3, *Salisbury Court, E.C.* ...	6d.
L'Electricien, 18, *Rue des Fosses, St. Jacques, Paris*	50 cts.
Electricity, 36, *Maiden Lane, W.C.*	1d.
Electrochemical and Metallurgical Industry, *New York*...	—
Der Electro Techniker, *Hengasse, 62, Vienna*...	60 pfs.
Elektrische Bahnen U. Betriebe, 8, *Gluckstrasse, Munich*	16 mks. p.a.
Elektrotechnische Rundschau, *Heiderstr, 100, Dusseldorf*, ...	6 mks. 6 mos.
Elektrotechnische Zeitschrift, *Monbijonplats, 3, Berlin, N. 24*	70 pf.
L'Elettricita, *Via Boccaccio, 3, Milan*	50 cts.
The Engineer, 33, *Norfolk Street, W.C.*... ...	6d.
Engineering, 35/36, *Bedford Street, W.C.* ...	6d.
Engineering and Mining Journal, 253, *Broadway, New York*	5 dols. per ann.
Engineering Magazine, 222, *Strand, W.C.* ...	1/-
Engineering News, 220, *Broadway, New York*	15 cts.
Engineering Record, 114, *Liberty Street, New York*	12 cts.
The Foundry, *Cleveland, Ohio, U.S.A.*.... ...	15 cts.
Gas World, 3, *Ludgate Circus Buildings, E.C.*	3d.
Le Génie Civil, 6, *Rue de la Chausssee d'Antin, Paris*	1 fr.
Giesserei-Zeitung, *Jerusalemer Strasse, 46/47, Berlin, S.W.*	40 pf.
Gluckauf, *Essen, A. D. Ruhr, Germany*	1 mk. 25 pf.
La Houille Blanche, *Grande-Rue, 23, Grenoble*	1 fr. 25 c.
Iron and Coal Trades' Review, 165, *Strand, W.C.*	6d.
Iron and Steel Magazine, 446, *Tremount Street, Boston*	50 cts.
Iron and Steel Trades' Journal, 5, *Hatton Garden, E.C.*	3d.
Iron Trade Review, *Cleveland, Ohio*	4 dols. 50 c. p.a.
Journal American Society of Naval Engineers, *Washington*	5 dols.p.a.
Journal of the Association of Engineering Societies, *Philadelphia, Pa.*	—
Journal of the Chemical, Metallurgical and Mining Society, *Johannesburg, S.A.* ...	2/-
Journal of the Franklin Institute, *Philadelphia, U.S.A.*	30 cts.
Journal of Gas Lighting, 11, *Bolt Court, Fleet Street, E.C.*	6d.
Journal of the Institution of Electrical Engineers, 92, *Victoria Street, S.W.* Single copies vary	1/6-7/6
Journal of the Iron and Steel Institute, 28, *Victoria Street, S.W.*	16/- per vol. 2 annually
Journal of the Royal Artillery, *Royal Artillery Institution, Woolwich*	2/6
Journal of the Society of Arts, *John Street, Adelphi, W.C.*	6d.
Journal of the Western Society of Engineers, *Chicago, U.S.A.*...	50 cts.
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School of Mines, Quarterly, *Columbia University, New York, U.S.A.* ... ... 50 cts.
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Stevens' Institute Indicator, *Hoboken, N. Jersey* 50 cts.
Street Railway Journal, 120, *Liberty Street, New York* ... ... 6d.

Technology Quarterly, *Institute of Technology, Boston, Mass.* ... ... 75 cts.
"Times" Engineering Supplement ... ... 3d.
Tramway and Railway World, *Amberley House, Norfolk Street, W.C.* 1/-
Transactions of the American Institution of Electrical Engineers, 26, *Cortlandt Street, New York* ... ... Price varies.
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Zeitschrift des Oestereichischen Ingenieur und Architekten Vereines 1, *Exchenbachgasse, Vienna*, 9... ... ... 70 h.
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Zeitschrift für Elektrotechnik, 7, *Nibelungenstrasse, 7, Vienna* ... ... 20 kr. p.a.

Civil Engineering.

Williamsburg Bridge, New York. *Engineering, 17th November* and *8th December*, 1905.

Concrete Floors without Ballast for Bridges and Roadway. *Railway Gazette, 17th November*, 1905.

Parabolic Concrete Arch Bridge over Piney Creek, at Sixteenth Street, Washington, D. C. *Engineering News, 16th November*, 1905.

Concrete Construction on the Cannington Viaduct, Axminster and Lyme Regis Light Railway. *Engineering News, 2nd November*, 1905.

The Pont de Commerce at Liége. *Proceedings Institute Civil Engineers, France, October*, 1905.

The Conflict of Engineers over Plans for the Panama Canal. *Engineering News, 30th November*, 1905.

The Irrigation System of the Godavari Deltas, Madras Presidency. *Public Works, October* and *December*, 1905.

The Queis Valley Dam at Marklissa. *Zeitsch. des Oesterr. Ingr. u. Arch. Vereines.* No. 45, p. 616.

The Landing Stage at Lome, Gulf of Guinea. *Engineer, 24th November*, 1905.

The Crowning Work of the Simplon Tunnel. *Engineer, 8th December*, 1905.

Notes on Stresses in Masonry Dams. *Engineering, 8th December*, 1905.

The Design of the Post Base of the Manhattan Bridge Towers. *Engineering Record, 25th November*, 1905.

Building.

Structural Details in a Maiden Lane Building. *Engineering Record, 18th November*, 1905.

Reinforced Concrete Building for the Park Square Motor Mart, Boston. *Engineering Record, 18th November*, 1905.

Reinforced Concrete applied to Modern Shop Construction. *Transactions American Society Mechanical Engineers, December*, 1905.

The Calculation of Concrete Arches reinforced with Profile Iron. *Beton und Eisen.* No. 11, p. 271.

Strains in Round Chimney Stacks. *Beton und Eisen.* No. 11, p. 273.

Calculation of Reinforced Concrete T-Girders. *Zeitsch. Oesterr. Ingr. u. Arch. Vereines.* No. 46, p. 631.

Ferro-Concrete Pipes. *Public Works, October—December*, 1905.

Large American Buildings. *Mem. Soc. Ing. Civil de France. October*, 1905.

Heating and Ventilation.

The Heating and Ventilation of Public and Private Buildings. *Public Works, October—December*, 1905.

Air Circulation in Cold Rooms. *Engineer, Chicago, 15th November*, 1905.

Materials and Measurements.

Tests of Reinforced Concrete Beams by the St. Paul Road. *Engineering Record, 11th November*, 1905.

Some Peculiarities of Cement. *Engineering Record, 4th November*, 1905.

Fire Tests with Concrete and Reinforced Concrete. *Engineering, 17th November*, 1905.

Elongation of Reinforced Concrete. *Beton und Eisen*. No. 11, p. 277.

Causes of Fracture in Straight Ferro-Concrete Girders. *Beton und Eisen*. No. 11, p. 279.

Determining the Moments of Inertia of Rotary Bodies. *Zeitsch. des Oesterr. Ingr. und Arch. Vereines*. No. 47, p. 642.

The Influence of Nickel and Carbon on Iron. *Engineering, 17th November*, 1905.

Note on the Irreversibility of the Hensler Alloys. *Physical Review, November*, 1905.

Boilers, Furnaces, and Fuel.

Advantages of Superheated Steam for Engines and Drying. *Engineer, Chicago, 15th November*, 1905.

Natural Gas under Steam Boilers. *Transactions American Society Mechanical Engineers, December*, 1905.

New Power Gas Generators. *Zeitsch. des Vereines Deutscher Ingenieure, 25th November*, 1905.

Pressure Drop through Poppet Valves. *Transactions American Society Mechanical Engineers, December*, 1905.

The Combined Rubbish Destructor and Power Plant in New York. *Engineering Record, 11th November*, 1905.

Tests of a Reducing Valve. *Railway and Engineering Review, 4th November*, 1905.

Results of the Preliminary Producer Gas Tests of the United States Geological Survey Coal Testing Plant at St. Louis. *Transactions American Society Mechanical Engineers, December*, 1905.

Engines and Motors.

Controlling Speed in Turbines. *Zeitsch. des Oesterr. Ingr. und Arch. Vereines*. No. 46, p. 621.

Regeneration and Superheating in Steam Turbines. *Zeitsch. des Vereines Deutscher Ingenieure*. No. 11, *25th November*, 1905.

The Balancing of Multi-Cylinder Petrol Engines. *Engineer, 17th November*, 1905.

Load Diagram of a Mill Engine. *Power, November*, 1905.

A New Valve Gear embodying a Novel Mechanical Movement. *Machinery, November*, 1905.

Conversion of Heat into Work by Adiabatic Expansion. *Power, November*, 1905.

Accidents Due to Faulty Piping and Incorrect Methods of Starting and Stopping Engines. *Power, November*, 1905.

The best Economy of the Piston Steam Engine at the Advent of the Steam Turbine. *American Machinist, 11th November*, 1905.

Simple Steam Turbine Engines, I. II. *American Machinist, 25th November* and *2nd December*, 1905.

Two New Steam Turbines. *Engineering News, 9th November*, 1905.

34 b.h.-p. Gas Engine for use with Producer Gas. *Engineering, 24th November*, 1905.

Possible Advantages of the Triple-Expansion Engine over the Compound. *Practical Engineer, 17th November*, 1905.

Gas Producer Plant and Gas Engines. *Public Works, October—December*, 1905.

Some new Designs of Single-Valve and Corliss Engines. *Engineer, Chicago, 1st November*, 1905.

Improvements in the Ball Engine. *Power, November*, 1905.

Gas Turbines. *Le Génie Civil, 2nd December*, 1905.

10,000 h.-p. Rolling Mill Engine, Cockerill System. *Le Génie Civil, 15th November*, 1905.

Hydraulics and Compressed Air.

Combined Air and Circulating Pumps. *Engineering, 17th November*, 1905.

An Unusual Pump. *Engineering Record, 25th November*, 1905.

Pump Piping, III. *Engineer, Chicago, 1st November*, 1905.

Air Compressors and Blowing Engines. *Practical Engineer, 24th November*, 1905.

Shop Equipment and Practice.

Lathe Design and Practice, II., III. *American Machinist, 4th* and *11th November*, 1905.

Moulding Machine Equipment. *American Machinist, 25th November*, 1905.

Machine Tool Design, XIII. *Engineer, 24th November*, 1905.

Turret Tools for Drilling Holes in Capstan—Head Screws and Nuts. *Machinery, November*, 1905.

Machine Shop Practice. *Proceedings Engineers' Society, Western Pennsylvania, November*, 1905.

Drilling and Boring Machines. *Engineer, 24th November* and *1st December*, 1905.

Lathe for the Manufacture of Zinc Shavings. *Engineering, 17th November*, 1905.

Making the Pattern and Mould for a Bed of a Power Press. *American Machinist, 2nd December*, 1905.

Machine Tools at the Liége Exhibition. *Zeitsch. des Vereines Deutscher Ingenieure, 18th November*, 1905.

Miscellaneous Mechanical Subjects.

Fans, II. *Machinery, November*, 1905.

Centrifugal Fans. *Proceedings Engineers' Society, Western Pennsylvania, November*, 1905.

Henrard Safety Catch for Mine Cages. *Le Génie Civil, 18th November*, 1905.

The Wharf Cranes of the Pennsylvania Railroad Company at Greenville, N. J. *Proceedings Canadian Society Civil Engineers, November*, 1905.

On the Location of the Pitch Circle in Worm Gearing. *Machinery, November*, 1905.

The Modification of Spring Action by Toggle Joints. *American Machinist, 11th November*, 1905.

The Bursting Strength of Cast-Iron Cylinders. *Machinery, November*, 1905.

Tests of Elevator Plant in the Trinity Building, New York City. *Transactions American Society Mechanical Engineers, December*, 1905.

Power Plant of the C. & N. W. Ry. Office Building. *Engineer, Chicago, 15th November*, 1905.

Belts and Belt Driving. *Zeitsch. des Oesterr. Ingenieur und Arch. Vereines.* No. 45, p. 609.

Railway and Locomotive Engineering.

Bogie Tank Locomotive, Madrid and Alicante Railways. *Engineer, 17th November*, 1905.

Two Baldwin 4-Cylinder Balanced Compound Locomotives. *Railway Gazette, 24th November*, 1905.

Valve Gear of the Symons' 4-Cylinder Balanced Compound Locomotive. *Railway Gazette, 24th November*, 1905.

Steel Cars for the New York Central's Electric Suburban Service. *Railway Gazette, 17th November*, 1905.

Consolidation Locomotive for the Imperial Government of Japan. *Railway and Locomotive Engineering, November*, 1905.

8, 10 and 12-Ton Private Owners' Wagons. *Railway Engineer, December*, 1905.

Ten-Wheel Coupled Locomotive for the G. W. Railway of Argentina. *Engineering, 24th November*, 1905.

Locomotive Water Space Stays. *Rly. Master Mech., November*, 1905.

Rebuilt Locomotive, Lehigh and New England R. R. *Railway and Engineering Review, 4th November*, 1905.

Four-coupled Express Locomotive for the Belgian State Railways. *Engineering, 1st December*, 1905.

Compound Locomotives with Superheaters. *Engineering News, 23rd November*, 1905.

Six-coupled 4-Cylinder Compound Locomotive; Paris, Lyons and Mediterranean Railway. *Engineering, 24th November*, 1905.

The Recent Development of the Locomotive Engine. *Engineer, 1st December*, 1905.

A Drop Bottom Stock Car. *Railway Age, 24th November*, 1905.

Locomotive and Car Journal Bearings. *American Engineer and Railroad Journal, November*, 1905.

High Capacity Goods Wagons. *Zeitsch. des Vereines Deutscher Ingenieure, 18th November*, 1905.

New Rack-Railway Locomotives. *Die Lokomotive*, No. 11, p. 164.

Provisions for End Shocks in Car Framing. *American Engineer and Railroad Journal, November*, 1905.

New Rail Motors, G. N. Railway. *Railway Gazette, 8th December*, 1905.

Some of the Advances in the Improvement of Track. *Railway and Engineering Review, 18th November*, 1905.

Wooden Sleepers, I. *Railway Engineer, December*, 1905.

The Chenoweth Reinforced Concrete Tie. *Engineering Record, 25th November*, 1905.

The York Process for Rolling Steel Ties from Old Rails. *Railway Gazette, 8th December*, 1905.

The Calculation of Railway Switch Curves. *Zeitsch. des Oesterr. Ingenieur und Arch. Vereines.* No. 48, p. 653.

Electric Equipment and Reconstruction of the New York Terminal Lines and Grand Central Station, New York Central and Hudson River R. R. *Engineering News, 16th November*, 1905.

Determining the Efficiency of Locomotives from the Curves of Velocity. *Zeitsch. des Oesterr. Ingenieur und Arch. Vereines.* No. 47, p. 637.

Electric Lighting of Railway Carriages by the Mixed System. *Zeitsch. fur Elektrotechnik, 26th November*, 1905.

Automobilism and Road Traction.

A Safety Starting-Handle. *Automotor Journal, 25th November*, 1905.

Middleton's Pneumatic Hub. *Autocar, 11th November*, 1905.

Details of the "Iris" Touring Motor Car. *Engineering, 17th November*, 1905.

The Siddeley 32 h.-p. Motor Car. *Engineering, 8th December*, 1905.

The "S 41" Type Petrol Motor Omnibus. *Automotor Journal, 9th December*, 1905.

Electric Lighting.

New Flaming Arc Lamp. *Electrical World and Engineer, 18th November*, 1905.

An Experimental Municipal Lighting Plant in New York. *Electricity, New York, 15th November*, 1905.

Electrical Generation and Transmission.

The Testing of Electric Generators and Motors. *Engineering, 24th November*, 1905.

The Niagara Power Plant of the Electrical Development Company of Ontario, I., II., *Engineering News, 9th* and *30th November*, 1905.

Electric Motors and their Applications. *Proceedings Engineers' Society, Western Pennsylvania. October*, 1905.

Niagara Power in Buffalo. *Electrical World and Engineer, 4th November*, 1905.

Niagara Power in the Gorge, I. *Electrical World and Engineer, 18th November*, 1905.

Influence of Armature Action on the Shape of Curve furnished by Polyphase Machines. *Zeitsch. für Elektrotechnik*, No. 47, p. 681.

A New Electric Power Scheme for London. *Engineering, 24th November*, 1905.

Electric Traction.

The Installation of Electric Traction on the Long Island Railroad. *Engineering News, 2nd November*, 1905.

Electric Traction at Bournemouth. *Tramway and Railway World, November*, 1905.

Single-Phase and Continuous Current for Traction Purposes. *Engineering, 24th November*, 1905.

Electric Traction by Monophase Alternating Current and the Auvert Ferrand Transformer. *Le Génie Civil, 11th November*, 1905.

Electric Postal Railway. *Le Génie Civil, 18th November*, 1905.

Heavy Electric Railroading. *Electrical World and Engineer, 18th November*, 1905.

Miscellaneous Electrical Subjects.

Measurement and Calculation o Losses in Synchronous Alternating-Current Motors. *Zeitsch. für Elektrotechnik*, No. 49, p. 713.

The "Telefunken" System of Wireless Telegraphy. *Rivista Tecnica*, No. 22, p. 339.

The Hydro-electrical Installations of Upper Italy. *Rivista Tecnica*, No. 22, p. 342.

Law of Electrical Penetration through solid Insulating Materials. *Zeitsch. für Elektrotechnik*, No. 46, p. 665.

Alternating-Current Electrolysis. *Western Electrician, 4th November*, 1905.

The Measurements of High-frequency Currents and Electric Waves. *Engineering, 1st December*, 1905.

Oscillographic Researches on Surging in High Tension Lines. *Proc. Can. Society Civil Engineers, 2nd November*, 1905.

The Measurement of High-frequency Currents and Electric Waves. *Engineering, 8th December*, 1905.

An Electric Accelerometer. *Proc. Can. Society Civil Engineers, November*, 1905.

Some Experiences with Lightning Protective Apparatus. *Electricity, New York, 8th November*, 1905.

Recent Researches in the Mechanism of the Electric Current. Ions and Electrons. M. Langevin. *Bulletin Soc. Int. des Electriciens, Paris.*

Zinc and Aluminium Fuses. *Electric Review, 17th November*, 1905.

Marine Engineering and Naval Architecture.

Ziurgevich's Patent Marine Engine Governor. *Steamship, December*, 1905.

Triple-Screw Turbine Driven Cunard Liner *Carmania*. *Engineering, 1st December*, 1905.

A Suction Gas Plant Boat. *Engineer, 1st December*, 1905.

The Dimensions of the Marine Steam Turbine. *Engineering, 8th December*, 1905.

New Motor Boats with Combustion Engines. *Zeitschrift des Vereines Deutscher Ingenieure, 11th November*, 1905.

750 Ton Steam Hopper Dredger. *Engineer, 17th November*, 1905.

Water Supply.

Electrically-driven Pumping, for Small Water Supplies. *Public Works, October—December*, 1905.

Sewage.

The Broadway Outfall Sewer, Borough of the Bronx, New York. *Engineering Record, 11th November*, 1905.

Vitrified Tile Sewers as House Drains in Chicago. *Engineering News, 2nd November*, 1905.

The Sewage Pumping Station at the Hampton Institute. *Engineering Record, 18th November* 1905.

Streets and Pavements.

Suggestions Covering Combined Curb and Gutter. *Engineering Record, 4th November*, 1905.

The Streets of the Future. *Beton und Eisen, November*, 1905.

Engineering Economics and Works Management.

Miscellaneous.

Methods of Rod-Holding in Stadia, Surveying and Description of a new Stadia Slide Rule. *Engineering News, 9th November*, 1905.

Some Problems in Internal Ballistics, from an Engineer's Point of View, I. *Journal Royal Artillery, November*, 1905.

Blowing up the Wreck of the *Chatham* in the Suez Canal. *Le Génie Civil, 18th November*, 1905.

Metallurgy at the Liége Exhibition. *Le Génie Civil, 11th, 18th* and *25th November*, 1905.

Working up Molten Pig Iron in Basic Martin Furnaces. *Stahl und Eisen*, No. 23, p. 1337.

Dissolved Acetylene Gas under Pressure. *Railway Master Mechanic, November*, 1905.

On the Measurement of Air Flowing into the Atmosphere through Circular Orifices in Thin Plates and under small differences of Pressure. *Transactions American Society Mechanical Engineers, December*, 1905.